LATENT CONTRACEPTIVE BEHAVIOR DYNAMICS AND PREGNANCY EXPERIENCES AMONG A NATIONAL SAMPLE OF U.S. WOMEN

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ABSTRACT

Alison Dora Swiatlo: Latent Contraceptive Behavior Dynamics and Pregnancy Experiences Among a National Sample of U.S. Women
(Under the direction of Siân L. Curtis)

Almost all women in the United States will use at least one contraceptive method at some point in their lifetime. Women are motivated to use contraception based on a sequence of decisions related to their particular circumstances, including sexual activity, method-related preferences, pregnancy intention and perceived risk of sexually transmitted infections. Of course, women also make contraceptive decisions within structural, social and cultural contexts. Race and ethnicity, social norms, and differences in socioeconomic status are associated with variances in contraceptive use and reproductive outcomes. The objective of this dissertation was to identify the existence and relative size of subgroups of latent contraceptive behavior in order to develop new hypotheses about contraceptive behavior dynamics.

Using data from 5539 women from the 2015-2017 National Survey of Family Growth, we used latent class analysis and latent transition analysis to capture the complexities of women's contraceptive experiences. In one calendar year, seven classes were identified based on contraceptive behaviors, sexual activity, and life stage, including a single mothers class, an intermittent users class, single abstinent women, stable users, women who frequently switch methods, women who prefer using condoms, and women with the greatest probability of pregnancy. Some of these classes were associated with sociodemographic variables. The LTA model examined how women transitioned among statuses over three-years, and how pregnancy affects contraceptive behavior transitions. Over half of the sample was reliably and effectively

using contraception and remained in the same contraceptive state over the three-year period. In any given study year, a small, dynamic risk profile emerged, identifying women who are unstable with their contraceptive use and at risk of unintended pregnancy. Pregnancy experiences also had distinctive effects. For some women, an unintended pregnancy triggered a change in contraceptive behavior. For others, it did not.

These trajectories describe heterogeneous health patterns in the US that underscore the complexities of women's fertility-controlling experiences and call for enhanced longitudinal integration of individual's contraceptive behaviors within family planning research and practice. This dissertation contributes to the evidence-base of reproductive health research, with the ultimate goal of informing quality family planning services focused on women's lived experiences.

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LIST OF ABBREVIATIONS

AIC	Akaike information criterion
BIC	Bayes information criterion
DHS	Demographic and Health Survey
EC	emergency contraception
FPL	federal poverty level
IUDs	intrauterine devices
LARC	long-acting reversible contraception
LCA	latent class analysis
LMR-LTR	Lo-Mendell Rubin likelihood ratio test
LRDT	likelihood ratio difference test
LRT	likelihood ratio tests
LTA	latent transition analysis
NSFG	National Survey of Family Growth
SSABIC	sample-size adjusted Bayesian information criterion

CHAPTER 1: INTRODUCTION

In the United States, there are around 61 million women of reproductive age (15 to 44 years old).[1] Most of these women will use contraception within their lifetimes in order to prevent an unintended pregnancy.[1] Family planning, including contraception and abortion services, has made an enormous impact on the health and social and economic opportunities and outcomes for women and their families. Not only is a family planning visit an entry point to the health care system and a usual source of care for many women, but also allows women and couples to successfully time and space pregnancies.[2] However, many women in the United States still find it difficult to access reproductive health services, use contraception effectively, or avoid pregnancies they do not want. And further, what we know about the psychosocial aspect of pregnancy and contraceptive intentions continues to evolve. Some women have mixed, fluctuating, or unresolved feelings and attitudes about using contraceptives and becoming pregnant.[3] Others, who might otherwise want to use a highly effective, long-acting contraceptive method, lack trust in the medical establishment to place and eventually remove such a device.[4] Within any given individual's life, combinations of these types of circumstances give rise to dynamic patterns of contraceptive and reproductive behavior. It is important to acknowledge and understand the heterogeneity of US women's contraceptive experiences in order to advance the evidence base for reproductive health behavior and family planning interventions.

Unintended Pregnancy in the United States

The rate of unintended pregnancy is a key reproductive health indicator across the world. Even though most women in the US will use some form of contraception at some point in their

lifetime, and overall a majority of the population is currently using contraception, unintended pregnancy in the United States is still very high compared to other industrialized countries.[5-7] Although unintended pregnancies have decreased in the United States in recent years, almost all of these pregnancies occur among women who either use contraceptive methods incorrectly, inconsistently, or use no method at all, with the remaining 5% a result of contraceptive failure.[2,8] In fact, prior analysis shows that 14% of women at risk of unintended pregnancy account for 54% of all unintended pregnancy.[2] For some women, unplanned or unintended pregnancy is associated with increased levels of stress and depression, delayed prenatal care, and increased likelihood of smoking and drinking during pregnancy.[9-11]

Unintended pregnancy also disproportionately affects low-income women and racial and ethnic minorities in the United States, a reflection of longstanding health disparities.[12,13] Across intrapersonal, interpersonal, organizational and community factors, this disparity underlines the complex and systemic influences in understanding health outcomes in the United States. For unintended pregnancies in the United States, Kim et al. 2016 found that factors such as age, relationship status, respondent's mother's age at first birth, Federal Poverty Level, and insurance status all contributed to the unintended pregnancy disparity between Black and white women. For Hispanic and white women in this same study, factors that contributed to this disparity included age, U.S. born status, education and relationship status.[14]

Relationship between Unintended Pregnancy and Contraception

There is some new evidence that shows that the increase of highly effective, long-acting reversible contraception (LARCs) use in recent years, such as intrauterine devices (IUDs) and implants, has contributed to the decline in the rate of unintended pregnancy.[15,16] However, Kavanaugh et al.[17] found that the increase in the use of IUDs and implants is not associated with a decrease in nonuse of contraception. The majority of increase in these methods is attributed to

women who were already using some form of contraceptive and who switched to highly effective methods. In fact, only 5% of unintended pregnancies in the United States occur to the large amount of women already using a contraceptive method consistently.[2] Although LARC use has increased, there has been no change in the percentage of women who are at risk of unintended pregnancy. In order for these methods to have a large effect on fertility and unintended pregnancy in the US, LARC methods would have to be adopted by women who do not use a method, use less effective methods, or use methods inconsistently.

The evidence from the last decade of LARC promotion points to the fact that not all women will ever "advance" to using highly effective methods of contraception.[18] Some women do not like the side-effects or menstrual changes of LARC methods. Other women prefer methods that they only have to use at intercourse or can stop using at any time.[19] As women age, their individual contraceptive behavior does not necessarily progress over time by type of method effectiveness. The decision to use contraception is a self-reflective, stage-sequential and discontinuous process that women repeat throughout their reproductive lives. It is important for clinicians and researchers to acknowledge the iterative decision process for every woman. The types of interventions needed to reduce levels of unmet contraceptive need involve disentangling barriers to women's access and knowledge of contraceptive methods, contraceptive preferences, and whether contraceptive nonuse is a long-term pattern or a temporary state triggered by method or relationship changes or other short-term changes in women's lives.[20]

Measuring Contraceptive Behavior

One of the key mechanisms to evaluating the success of family planning interventions is through what we choose to measure and how.[21] Most research studies present cross-sectional measures of contraceptive use which can imply that women who do not use contraceptives are a static group and are unable or unwilling to obtain and use contraceptive methods. In reality,

many of these "nonusers" actually have used a method of contraception at some point in the recent past, and some "current users" have experienced periods of nonuse during which they were at risk of unintended pregnancy.[20] However, longitudinal studies that describe women's contraceptive experiences over time are rare. Most of these studies focus on method continuation, a concept that is highly related to medication compliance in clinical studies. Very few research studies focus on individual contraceptive behavior over time, begging the question about what happens to a woman when she discontinues a contraceptive method, does she adopt another method? Or abandon contraceptives for another reason, and for how long? And how do these transitions affect her reproductive experiences? Rather than focusing on the yes or no success or failure of a woman using a high-effective and long-term contraceptive method, measuring contraceptive behavior from a person-centered approach recognizes the respondents' agency and decision-making in their own life.[21]

Contraceptive behavior patterns will look different for every woman, but there are certainly patterns that can be gleaned from examining reproductive behavior across populations. The experience of a young, sexually active college student is very different when compared to a married woman in the midst of her active reproductive years who may be concerned about infertility, wants to ensure a healthy pregnancy or to space her childbearing. It is different still for an older woman who wants to prevent additional pregnancies. Cross-sectional studies or studies that focuses on discrete-choice models with one dimension of contraceptive method type as the outcome cannot adequately describe these dynamic patterns.

Trajectory Approach to Health Behavior Analysis

Traditionally, the dominant methodological approach in social science has been to explain relationships between variables of interest in a population i.e. correlation, regression, *t* tests, etc.[22] However, advances in statistical theory coupled with more efficient computers have

fostered the development of new approaches for modeling longitudinal individual development, such as hierarchal linear models, growth mixture models, and semi-parametric group-based trajectory models.[22] Unlike variable-centered approaches where all individuals from a sample are assumed to be drawn from a single population for which a single set of "averaged" parameters can be estimated, these person-centered methodologies relax this assumption and consider the possibility that the sample might include multiple subpopulations characterized by different sets of parameters.[23] Person-centered methodology is used to identify the dynamics of emergent sub-populations in a sample based on an array of chosen variables and understand the relations of these subpopulations with predictors, correlates, or outcomes.

Latent Class Analysis (LCA) and Latent Transition Analysis (LTA) are examples of person-centered methodology. They are advantageous for modeling classes and trajectories of class membership when the construct of interest is assumed to be categorical in nature and to change over time in a discrete manner.[24] Change is represented by the movement over time between distinct stages of multiple variables. One example, Mooney et al.[25] used LTA to determine nuanced patterns of physical activity such as gardening, walking, housework, as well as neighborhood determinants of changes in activity patterns, over a two-year cohort of 2,000 adults. Landau et al.[26] were able to document clinical subtypes with LTA using several depression and anxiety variables in Parkinson's disease patients over a four-year period. Lanza and Collins[23] explored dating and sexual risk behavior dimensions, such as sexual intercourse, number of sexual partners, and inconsistent condom use, longitudinally in young adults. The authors found that gender and substance use were associated with sexual risk behavior transitions over time. One recent study from Shepherd and Marshall[27] published in the *Journal of Marriage and Family* used latent class analysis to partition respondents into groups based on

multidimensional attitudes about childbearing worldviews and then examined the contraceptive behavior among those groups. They identified six classes of young women that shared latent childbearing worldviews and found that the latent classes show distinct patterns of consistent, inconsistent and abstinent contraceptive behavior for each class.

Contraceptive use is a multidimensional behavior and what is often of interest is not a woman's method use at a singular point in time but rather a profile of her reproductive behavior over a period of time. Quantifying the different pathways and patterns of contraceptive use behavior that individual women tend to follow allows researchers and clinicians to form a clear picture of different "types" of individuals that exist in this population. No set of patterns will contain the definitive list of the ways in which all individuals use contraception but documenting these patterns over time is a way to summarize variability in individual trajectories. Latent transition analysis allows researchers to model multidimensional latent variables and how they interact and evolve over time. It provides a way to estimate and test models of stage-sequential development. To this end, latent class and latent transition analysis will be used in this dissertation to identify underlying classes of individuals based on observed contraceptive behaviors and life-course factors, and to model individuals' movement between latent contraceptive behavior typologies across time.

Dissertation Research Aims

The objective of this dissertation is to better understand individual patterns of dynamic contraceptive behavior, the associations between those patterns and sociodemographic characteristics, and how pregnancy affects patterns of contraceptive behavior in a population of US women from adolescence to adulthood. I hypothesize that a specific set of trajectories will exist among this population of US women. In addition, these patterns will be related to demographic characteristics and sociocultural contexts such as age, education, socioeconomic

status, race and ethnicity, and religion. Finally, I hypothesize that pregnancy experiences affect women's transition patterns between different contraceptive behaviors typologies.

This dissertation will use three years of National Survey of Family Growth (NSFG) calendar data from 2015-2017 to examine patterns of dynamic contraceptive use behavior among a nationally representative sample of US women ages 15 to 49. This analysis is believed to be the first such application of these methods to nationally representative, longitudinal U.S. data on contraceptive behavior. The analyses will address the following specific aims:

Aim 1: Identify Latent Class Patterns of Contraceptive Behavior Status in Study Year 1

Aim 1 uses latent class analysis, a latent variable measurement model, to identify qualitatively distinct patterns of heterogeneity among individuals' patterns of contraceptive use behavior. The fundamental idea behind latent class models and person-centered methodological approaches is that individuals can be probabilistically assigned into *unobserved* subgroups based on their responses to multiple *observed* indicators. Eight different indicators of contraceptive behavior and life-stage inform the latent classes: type of method used most frequently over the study year, condom and emergency contraception use frequency, inconsistent contraception use, sexual activity, frequency of contraceptive method switching, marital status, and parity. Aim 1 of this dissertation is (a) to identify individual contraceptive behavior patterns based on a series of variables created from responses in the National Survey of Family Growth contraceptive calendar and (b) to determine the relationship between latent classes and sociodemographic characteristics of individuals including race and ethnicity, income, education, and religion. This aim is explored in Chapter 2.

Aim 2: Identify Longitudinal Transitions Patterns of Contraceptive Behavior Status.

Aim 2 uses latent transition analysis, a longitudinal extension of the latent class analysis model used in Aim 1. Aim 2 of this research is (a) to estimate the incidence of transition in latent

contraceptive behavior dynamics (where t=1, t=2, and t=3 for every study year in the 2015-2017 NSFG calendar data set) and (b) to assess whether the same sociodemographic and social characteristics predict a greater likelihood of transitions among some latent statuses compared to others. This aim is explored in Chapter 3.

Aim 3: Examine the Effects of Pregnancies on Transition Patterns.

Using the latent transition statuses derived in Aim 2, I describe the effects of both unintended and intended pregnancies on latent contraceptive behavior patterns. Aim 3 of this research is to test the hypothesis that unintended pregnancies have a distinct effect on contraceptive behavior transition patterns compared to intended pregnancies. This aim is explored in Chapter 3.

CHAPTER 2: ONE-YEAR LATENT CONTRACEPTIVE BEHAVIOR IN A NATIONAL SAMPLE OF U.S. WOMEN

Background

Almost all women in the United States will use at least one form of a contraceptive method at some point in their lifetime [28]. According to a national study, the average woman who uses reversible contraception methods from her 15th to her 45th birthday will start and stop methods of contraception nearly 10 times.[29] Most research studies that focus on individual contraceptive behavior describe one dimension of use, such as time to discontinuation of a method or postpartum use. [30,31] However, women's contraceptive use behavior is not sufficiently described by such unidimensional analysis. Throughout their lives, women are motivated to use contraception based on a sequence of decisions and behaviors related to their particular circumstances, including method-related preferences, pregnancy intention and perceived risk of sexually transmitted infections. [32] Women also make these contraceptive decisions within structural, social and cultural contexts. Race and ethnicity, social norms, relationship status, socioeconomic circumstances, and access to high-quality health care have all been associated with differences in contraceptive use in the United States.[33]

The objective of this study is to better understand the multiple dimensions of individual's contraceptive behavior over the course of one calendar year. Latent class analysis (LCA) is a specific type of latent variable model that is used to parse underlying variation among individuals in a population. Using LCA, this study aims to capture (a) qualitatively distinct subgroups of women in the US who demonstrate particular contraceptive and reproductive

behavior typologies; and (b) sociodemographic variables associated with these typologies.

Contraceptive Behavior in the United States

In the 2015-2017 National Survey of Family Growth (NSFG), a probability-based, nationally representative survey conducted by the Centers for Disease Control and National Center for Health Statistics, 64.9% of US women aged 15-49 were using contraception at the time of the survey interview.[1] The most common methods used were female sterilization (18.6%), oral contraceptive pill (12.6%), long-acting reversible contraceptives (LARCs; including intrauterine devices and implants) (10.3%), and male condoms (8.7%). Use of the contraceptive pill was higher among White women (14.9%) compared to Hispanic (9.2%) and Black women (8.3%). Contraceptive use also varied by education levels. Female sterilization declined with higher education – 32.1% of women who completed high school were using female sterilization for contraceptive reasons compared with 11.3% of women with a college degree or higher. Pill use also increased with higher education – 4.9% of women without a high school diploma were using the pill compared with 16.3% of women with a college degree or higher. The percentage of women using condoms was lower among women with a high school diploma (5.8%) compared to women without a high school diploma (11.1%) and women with a college degree or higher (11.4%). [1]

Dynamic Patterns of Contraceptive Use

Contraceptive use is associated with life stage and varies dynamically with age, relationship status, and family building intentions. Previous studies have described how gaps in use, inconsistent or incorrect use, and barriers to contraceptive use change with age. From the 2015-2017 NSFG data, use of long-acting reversible contraception was higher among women aged 20-29, while female sterilization increased with increasing age, and use of the pill decreased with increasing age.[1] Pazol et al. found that stable contraceptive use, defined as use of

contraception at some point during every at-risk month and last sexual intercourse, was highest for teens and then decreased across age groups. Sporadic contraceptive use, defined by contraception use during some but not other at-risk months or at some point during at-risk months but not at last intercourse, was lowest for women in the oldest age group. The motivations for nonuse or discontinuation also differed by age group. For teens, nonuse correlated with contraceptive method dissatisfaction while, for older women, the intention to have children in the future and reported fertility issues were both associated with nonuse of contraception and sporadic contraception use.[34]

Fluctuating relationship dynamics also play an important role in contraceptive behavior. The type of relationship, level of intimacy, and the duration of the relationship are significantly associated with using effective contraceptive methods.[35-37] One study found that among unmarried young women who wanted to avoid pregnancy for at least one year, women in casual relationships were less likely to use effective contraceptive methods (pill, patch, vaginal ring, DMPA, implant, or IUD), compared to women in longer-term relationships. [37] Women in new relationships (0 - 3 months) were also less likely to use effective contraceptive methods compared to women in relationships more than one year. Other research corroborates the link between relationship status and contraception. Wildsmith et al. found that within dating relationships, couples that reported less intimacy had greater odds of condom use. However, cohabiting couples were less likely to use contraception at last sex than dating couples. [36]

Individual patterns of contraceptive use are important to study given that effectiveness varies with each woman's time using a method and method choices can change frequently. [38] Prior research on initiation and discontinuation of contraception shows that women start, stop, and switch methods over time. For example, the median number of specific methods ever used

by a single woman in a national sample in the US was 3; however, nearly 30% of women have used five or more methods in their lifetime. [28] These numbers suggest that method switching and discontinuation are common. In fact, 47% of women who have used at least one method of contraception have discontinued using a method due to dissatisfaction and there is a wide difference in discontinuation among specific methods. [28] Women report many reasons for method switching and discontinuation including concern that the method will not work, dissatisfaction with the method, and side-effects such as irregular bleeding.[29]

Much of the available research on individual contraceptive behavior patterns focuses on single episodes of contraception. For example, studies have documented short-acting method continuation within 1 year and found that discontinuation rates are high for male condoms, withdrawal, fertility-awareness based methods, and lower for oral contraceptives and the hormonal ring.[39,40] Another research study found that within one year, contraception was abandoned altogether by 25% of participants, although some resumed use in later months. [41] Continuation rates for long-acting reversible contraceptives (LARCs) are relatively high. [41,42] After adjusting for various demographics, the adjusted hazard ratio for discontinuation was three-times higher among non-LARC method users than LARC users.[41] Another study found similar results among young women less than 25 years of age in a 30-month time frame.[43]

There is very little research that examines the continuity of use by individuals rather than by method. One 2007 study surveyed 1,978 adult women at risk of unintended pregnancy by telephone about their previous 12-month contraceptive use.[20] Data from this nationally representative sample were used to construct typologies according to women's level of potential exposure to the risk of unintended pregnancy. Thirty-eight percent of women reported using the same method every month for the entire year, while 24% used a method every month but

reported that they had switched methods at least once. Fifteen percent experienced at least a month of nonuse when they were at risk of pregnancy, and another 15% had gaps in use during which they were sexually inactive or pregnant. Eight percent of women were consistent nonusers and did not use contraception during any month that they were sexually active within the year.

Two recent studies, one with young adult women in the US and one international study of women aged 15-49, were able to identify contraceptive behavior profiles using longitudinal data.[44,45] The US study, Brew et al. 2020, used a weekly panel of 581 young adult women and sequence and cluster analysis to identify relationship status, sexual activity, and contraceptive use trajectories among 18 and 19-year-old women in Michigan. They found six common sequences (1) women not in a relationship, (2) in a non-coresidential relationship without sex, (3) transitioning frequently in and out of non-coresidential relationships without sex, (4) transitioning frequently in and out of a non-coresidential relationship with sexual activity and contraceptive effectiveness, (5) frequently rely on less effective contraception in sexual relationships, and (6) in a co-residential relationship using effective contraception. MacQuarrie et al. did a similar analysis with women ages 15-49 in Burundi and Nepal using five years of Demographic and Health Survey calendar data. A sequence and cluster analysis of contraceptive profiles, based on contraception and pregnancy status, found six distinct subgroups of women's reproductive behavior in these two countries, including "Modern Mothers" who adopt short-term modern methods such as birth control pills, "Consistently Covered Mothers" who use long-acting methods, and "Family Builders" and "Quiet Calendar" both of whom do not use contraception, and either become pregnant multiple times ("Family Builders") or do not ("Quiet Calendar") [45]. Compared to the US, Burundi and Nepal greatly differ in healthcare contexts and social norms surrounding family planning and childbearing. However, these are new studies that

use a person-centered approach to examine individual-level patterns of contraception use over time.

Current Study Hypothesis

Unlike variable-centered approaches where all individuals from a sample are assumed to be drawn from a single population for which a single set of "averaged" parameters can be estimated, person-centered methodologies like LCA relax this assumption and consider the possibility that the sample might include multiple subpopulations characterized by different sets of parameters.[23] LCA can be used to identify the dynamics of emergent sub-populations in a sample based on an array of chosen variables and understand the relations of these subpopulations with predictors and outcomes. The goal of this study is to characterize individual patterns of contraceptive behavior over one year and to identify typologies of contraceptive behavior. Documenting these patterns is a way to summarize heterogeneity in individual experiences.

The contraceptive calendar is a longitudinal component of the NSFG. It is an underutilized source of data which can be used to analyze recent periods in women's contraceptive experiences.[46] The current study is believed to be the first such application of these methods to nationally representative longitudinal contraceptive data in the US.

This research study aims to capture how multiple systems, socio-cultural factors, and behaviors overlap with one another to produce patterns of contraceptive use behavior. Informed by previous literature on contraceptive use patterns, several different classes are hypothesized to be identified from latent class analysis.[44,45] These classes include:

1) *inconsistent users:* women who use the least effective methods, such as frequently switching between no method and least effective methods, have sexual intercourse.

2) *family builders*: women who do not use any methods, are married, and have low parity.
3) *consistently covered mothers*: women who adopt effective methods, most likely already have children; married or had a marriage dissolution; older
4) *consistently covered non-mothers*: women who adopt effective methods, may also frequently use condoms; single; younger
5) *abstinent women:* women who do not use contraception because they are not having sex frequently.

Methods

Participants and Procedure

Data for this analysis come from the most recent round of the NSFG conducted in 2015-2017. The NSFG is conducted in home with face-to-face interviews of men and women aged 15-49 years, oversampling for non-Hispanic Black participants, Hispanic participants, and teens aged 15-19.[47] In total, 5,554 women were interviewed in the 2015-2017 data collection round. The NSFG does not follow the same women over time; however, the NSFG has a longitudinal component: the contraceptive calendar. The NSFG's contraceptive calendar captures contraceptive method(s) female respondents used each month for the time period from the January three years prior to the interview date, through the interview date. For example, for women interviewed in October 2017, the contraceptive calendar collects monthly information from January 2014 through October 2017. The first year of reported contraceptive calendar data for each respondent was used for this analysis. So, for the participant who was interviewed in October 2017, this study would capture her contraceptive behavior from January to December of 2014. Stata 16.0 (StataCorp, College Station, TX) was used for data management while Mplus 8.4 (Muthén and Muthén, 2019) was used for analyses.

Measures

Six contraceptive behavior indicators were created from year 1 of the NSFG calendar data to describe contraceptive behavior typologies. In the calendar, women reported contraceptive use and sexual activity with an opposite sex partner in that month. Two life stage variables – marital status and parity – were also included in our analysis using data from the larger NSFG survey and constructed to reflect the status of these variables during calendar year 1. The NSFG does not distinguish pregnancy months in the calendar data in the public data file. Therefore, women who were pregnant during the year will be characterized based on other indicators.

Most frequent type of method. Participants were able to report up to four methods of contraception used in each calendar month. Using the primary method reported in each month, methods were grouped into four categories of effectiveness:

1. Most effective (sterilizations and vasectomy, IUDs, coil, loop, and hormonal implants)
2. Moderately effective (birth control pills, Depo-Provera, contraceptive patch, and vaginal contraceptive ring)
3. Least effective (barrier methods – female and male condoms, withdrawal, foam, jelly, suppositories, diaphragms and caps, and natural family planning – calendar rhythm, standard days or cycle beads, and safe periods)
4. No method

Based on the number of months respondents reported using each of these four method groups, the most frequent type of primary method was documented during the study year[1] for each

[1] Some respondents reported using two different categories of methods for the same number of months within the year. These observations were examined and found to be a very small number of women. Therefore, these women were grouped by the most effective method of contraceptives they used, among the mixed methods.

participant.

Condom Use Frequency. The number of months the participant used condoms during the study year. This variable documented condom use by examining all of the four possible methods a woman could report each month. For example, if a respondent said she used the pill as her first method, and then said she used condoms as the second method, condom use would be reported within that study month for that participant. This variable was recorded from 0 to 12 months of condom use during the year. It was coded separately because condoms also protect against sexually transmitted infections.

Emergency Contraception Frequency. The number of months the participant used emergency contraception (EC) during the study year. This variable uses all 4 mentions of contraceptive method types that a woman could report over the course of one month. This variable is categorized as 0 for no EC use during the calendar year and 1 for any EC use during the year.

Sexual Activity Frequency. The number of months the participant was sexually active with an opposite sex partner during each study year. The NSFG asks about any occurrence of sexual intercourse during that month and does not distinguish vaginal intercourse from other forms of sexual intercourse. This variable is categorized as 0 to 12 months of sexual activity during the year.

Inconsistent Contraception Use. The number of months a participant was sexually active and simultaneously not using a method of contraception. This variable includes months when women were pregnant or were trying to become pregnant, but not exclusively. This variable is categorized as 0 to 12 months of inconsistent contraceptive use during the year.

Frequency of Contraceptive Method Switching. The frequency of switching different method types, based on the four categories of contraception described above. Since there are 12 months in a year, a participant may switch contraception methods up to 11 times in one study year. Due to sparseness, method switching is collapsed to 0, 1, 2 or more contraceptive method changes.

Marital Status. Participants' marital status during calendar year 1. Women were categorized as "single in the study year, never been married, "single in the study year, had a previous marriage," "married throughout the year," "got married in the study year," and "had a marriage dissolution[2] in the study year." A participant might have multiple marriage events in the study year e.g. got married and had a marriage dissolution in the study year. The participant is categorized by the last event that occurred in that year. For example, if she entered the study year married, divorced within the year, and remarried in the year then she would be categorized as "got married in the year."

Parity. Parity is measured by total number of pregnancies that ended in live births. Parity during calendar year 1 was constructed by subtracting the number of live births since the start of the calendar year from the parity at the time of the interview.

Covariates

Age. Age in the first year of the contraceptive calendar is approximated by respondents' age at the time of interview minus three years. Age is grouped into categories 13-17, 18-22, 23-27, 28-32, 33-37, 38-42, 42-47.

Education. Education is measured using the highest education level achieved by the respondent, measured at the time of the interview.

[2] Marriage dissolution may include divorce or spousal death.

Race. Race was measured in the screener questionnaire of the NSFG. Responses include White, Black or African American, Hispanic, and Other race groups. The public use data file reports a collapsed race variable to minimize risk of inadvertent disclosure. Other race includes American Indian or Alaska Native, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese or Other Asian, Native Hawaiian, Guamanian or Chamorro, Samoan or Other Pacific Islander.

Federal Poverty Level. Poverty level of the respondent is measured by whether their family income is <138%, 139-199%, 200-299%, 300-399%, and 400 percent or greater of the Federal poverty level (FPL) at the time of the interview. The FPL category of <138% represents the minimum poverty level threshold in which a participant would qualify for Medicaid and other public programs, in states that have not expanded Medicaid eligibility [48].

Religion. Religion is measured by current religious affiliation including no religion, Catholic, Protestant, or "Other" religions, including Jewish, Mormon, Greek Orthodox, Muslim, Buddhist, Hindu, etc.

Analytic Approach

Latent class analysis (LCA) is a specific type of latent variable model that is used to parse underlying multivariable variation in a population.[24] LCA is used in this analysis to identify subgroups of latent contraceptive behavior dynamics based on probable class membership derived from the eight contraceptive behavior, life stage, and exposure variables. Number of months of sexual activity, inconsistent contraceptive behavior, and condom use in the calendar year were treated as count variables in the model. Most frequent type of method used, marital status, parity, emergency contraceptive use, and method switching across the calendar year were estimated as categorical variables in the model. Based on the conditional probabilities of

particular response patterns across the observed contraceptive behavior and exposure variables, individuals are assigned to latent classes with an estimated probability.

After estimating latent classes, we analyzed the relationship between class membership and the predictor variables including age group, education, race and ethnicity, religion, and federal poverty level. We used multinomial logistic regression with a three-step approach bias-correction method that adjusts the relationship between predicted class membership and external variables to account for misclassification probabilities.[49]

Results

Sample Characteristics

We restricted our analytic sample to women respondents with complete contraceptive calendar data. A total of 15 women, or 0.3% of the eligible participants, were dropped due to missing data yielding an n=5539. Table 1 summarizes the calendar year variables and sample characteristics. For method type, 22.0% of women used the most effective method types during the majority of the first calendar year, while 18.0%, 14.8% and 45.2% used moderately effective, least effective, and no method, respectively during the majority of the first calendar year. More than three quarters of the sample, 78.2%, never used condoms during the study year and 7.6% used them every single month. Most women in the sample never used emergency contraception, but slightly over 1.0% used it at least one time during the year. A large portion of the sample (46.7%) had sex every month of the study year, however, another group (29.6%) did not have any months of sexual activity in the year. The majority of women (81.0%) were either not having sex or were using contraceptives every month that they did have sex, while 7.0% had sex every month of the year and never used contraception. For method changes, most women, 78.3%, never switched contraceptive method during the study year; 12.8% switched methods once and 8.9% switched twice or more. A majority of the sample (58.3%) was single and never married

throughout the study year, 28.2% were married throughout the study year, 9.7% were single but previously married. Almost half (49.4%) of the sample had 0 children, 19.3% had 1 child, 17.2% had 2 children and 14.1% had 3 or more children.

In terms of social and demographic characteristics (Table 2), 21.0% of women were in the youngest age group (13-17), and around 15-16% were in each older age group 18-22, 23-27 or 28-32. The sample proportions declined with increasing age group after 32. Almost a quarter (23.6%) did not have a high school diploma, 22.6% were high school graduates, 26.4% had some college while 27.4% had a college degree or graduate/professional level education. The largest single race group was white (48.2%), about a quarter of the participants were Black (24.1%) and 19.3% were Hispanic. A large portion of the sample (37.7%) were below 138% of the Federal Poverty Level, while 14.9% were 139-199%, 15.4% were 200-299%, 9.8% were between 300-399%, and 22.3% had household incomes that were at or greater than 400% of the Federal Poverty Level. Almost half (49.0%) of the sample identified as Protestant, 19.9% as Catholic, 22.7% as having no religion, and 8.3% as "other" religions.

Model Selection

An important step in model selection is determining the number of latent classes. The number of classes was selected based on interpretability of the models and examination of standard goodness of fit indices including the log-likelihood value, the Akaike Information Criterion (AIC), Bayes Information Criterion (BIC), sample size adjusted BIC, and the Lo-Mendell Rubin Likelihood Ratio test. The AIC, BIC, sample-size adjusted BIC were lowest for the seven-class model. We also considered whether models with five and six classes provided more parsimonious interpretation. However, we determined that the seven-class model provided the optimal statistical solution with interpretable, distinct classes (Table 3).

Class Characteristics

Table 4 describes the probabilities and means of the eight latent class variables for each of the seven latent classes identified.

1. *Single Abstinent Women* comprised of 25% the sample and included women who were single, never married, did not have children, and rarely, if ever, had sex. A large majority (89%) used no method of contraception.
2. *High Chance of Pregnancy* made up 12% of the sample. This group did not use methods of contraception but, unlike the first class, frequently had unprotected sex. Almost 50% of these women are married, but 37% were single, never married. Most of this group were already mothers, with around 67% having children.
3. *Intermittent Users* consisted of 8% of the sample and the class was characterized by having sex occasionally, using condoms infrequently, and rarely having unprotected sex. They mostly used no method or a moderately effective method and 76% of them switch methods, with over 45% switching more than twice in the calendar year. They used emergency contraception more than any other class and were mostly single, never married and almost 70% had 0 children.
4. *Single Mothers*, comprised 6% of the sample and consisted of women who had at least 1 child (92%), and either were single, never married (30%) or single, previously married (47%) or had a marriage dissolution within that year (6%). These women mostly use the most effective methods or nothing at all, and they do not switch methods. They rarely had sex.
5. *Method Switchers,* consists of 5% of the sample, the smallest class, and are characterized by their method switching. All of the women in this class switched contraceptive method type during the calendar year. They had sex regularly, and occasionally used condoms

but also occasionally had unprotected sex. Most of them used no method most frequently, but 24% used moderately effective methods, 22% used least effective methods, and 17% used most effective methods most often. A third do not have any children but the majority had a least one child. They are mostly single, never married, but also are made up of around 42% married women.

6. *Condom Users* (13%) use condoms regularly and have sex regularly, and rarely have unprotected sex. Most did not switch methods during the year. Condom Users are mostly single and about half (49%) have children.
7. *Stable Users*, are the most prevalent class (31% of the sample). They are characterized by having regular sexual activity but never using condoms or having unprotected sex. They most often use some method of contraception (96%) and the majority use the most effective methods (54%). These women are mostly married (49%) but some are single, never married (36%). This class has relatively equal amounts of parity groups (0, 1, 2 and 3 or more children). Most of this class never used emergency contraception or switched contraceptive methods.

Covariates

A seven-class multinomial logit model with the three-step correction was fitted with sociodemographic predictors to explore whether these variables correlated with contraceptive behavior class. In Table 5, we present the predicted probabilities of class membership, derived from model estimates shown in Appendix 1. For the predicted probabilities, we varied each covariate of interest while holding all others at their observed values. The results suggest that the 13-17 and 18-22 years old groups were more likely to be in the *Single Abstinent* women class. As age group increases, the probability of being in the *Stable Users* group also increased. The probability of being in the *Intermittent Users* class increases with education. Women with

college degrees or higher education were more likely to belong in the *Single Abstinent* than women with less than a high school degree, compared with the *Stable Users*. Women with "some college" had a high probability of being in *Intermittent Users* and *Condom Users*. Black women had a high probability of being *Single Abstinent* women, *Intermittent Users*, *Single Mothers*, and *Condom Users*, while women who identified as an "Other" race had a high probability of being in *High Chance of Pregnancy* class. Income that was 300-399% percent of the federal poverty level was associated with decreased likelihood of being in *High Risk of Pregnancy*, *Intermittent Users*, and *Single Mothers*, while women with income greater than 400% of the FPL had low probabilities of being in *Single Abstinent* women, *High Chance of Pregnancy*, *Single Mothers*, and *Condom Users*.

Discussion

To our knowledge, this analysis is the first application of person-centered methodology – latent class analysis – to nationally representative contraceptive calendar data in the US. One goal of this analysis was to develop new ways to characterize the nuance of women's contraceptive experiences and to describe how these experiences manifest in various stages of life. By using latent class analysis, we determined that there are distinct patterns of latent and dynamic contraceptive behavior in the US population. Expanding on prior contraceptive behavior literature that focuses on contraceptive experiences at single points in time, these subgroups elucidate group patterns not only on method choice, but across eight different factors of contraceptive behaviors and life stage.

Seven classes were identified that capture the heterogeneity in contraceptive behavior dynamics across one calendar year: *Single Abstinent*, *High Chance of Pregnancy*, *Intermittent Users*, *Single Mothers*, *Method Switchers*, *Condom Users* and *Stable Users*. Most of these US women were *Stable Users* (31%) or *Single Abstinent* women (25%) which suggests that over half

of reproductive-age US women were either not having intercourse or reliably using contraception when they had intercourse. Some women prefer to mainly use condoms (13%) or perhaps intermittently use protection when they have sex (8%). A small portion of women (6%) are characterized by already being mothers, unmarried, and rarely having sex. While the smallest group (5%) are switching methods throughout the year, sometimes having unprotected sex, and are generally unstable in their contraceptive behavior. The remaining 12% are at high chance of pregnancy. This group most likely includes women who are already pregnant or are trying to become pregnant, as well as those women who do not use contraception at all but may not want to become pregnant.

In a similar person-centered analysis among women in Burundi and Nepal, MacQuarrie et al. examined contraceptive profiles but only captured change in one contraceptive dimension at a time.[45] There are some similarities among the contraceptive typologies they identified and those in this analysis although Burundi and Nepal are exceptionally different contexts than our US national sample. Women in the *High Chance Pregnancy* class in the US are similar to the Family Builders in Nepal and Burundi, women who do not use any method, have unprotected sex, and have a high probability of becoming pregnant. Consistently Covered Nepalese women resemble *Stable Users* in the US, as these women steadily use either LARC or short-term effective methods. Although MacQuarrie et al. examine dynamic contraceptive behavior over a 5-year time period, our 1-year study expands on their research by adding multiple, important layers to the contraceptive profile including sexual activity, method switching, and parity. These layers add important exposures and life stages context among our sample of US women in order to further understand how contraceptive behavior, relationships, and parity evolve together.

In a US study that used data from the Relationship Dynamics and Social Life study of young women, researchers used latent class analysis to identify six typologies of young women who share childbearing worldviews, as measured by attitudes around sex, personal aspirations and having children, and found that membership in those classes predicted contraceptive behavior.[27] Their results identified 1) "General Skeptics" who supported sexual activity regardless of relationship status but had negative attitudes towards birth control 2) "Meaningful Motherhood" who felt positive about motherhood, and had negative attitudes towards birth control 3) "Family Conservatives" with negative views of sexual activity outside of marriage and the most negative attitudes about birth control 4) "Have-it-all" class who were very positive about family life and positive beliefs about birth control 5) "Planners" had negative attitudes about sexual activity outside of marriage but felt positive about birth control and finally 6) "Motherhood Skeptics" who were the most negative about motherhood. "General Skeptics," "Have-it-alls," "Planners" and "Motherhood Skeptics" had a lower relative risk of inconsistent contraceptive use compared with the "Meaningful Motherhood" group. The results of this study indicate that attitudes around childbearing and contraceptive behavior in the US may speak to some of our results. Women with negative attitudes towards birth control may be less likely to use more effective methods or use any contraceptive at all such as in our *High Chance of Pregnancy* and *Method Switchers.* Further research on the dynamic nature of both contraceptive and childbearing intentions is needed.

In the second part of this analysis, we examined determinants of class membership including age, race and ethnicity, education, federal poverty level and religion. In our study, teenage women (13-17 year old group) were overwhelmingly more likely to belong to *Single Abstinent* women, while a small number were classified into *Intermittent Users* or *Condom Users*

compared to those in the *Stable Users* class. In the next age group, 18-22 year old women were still more likely to be in the *Single Abstinent* group but more of these women were *Condom Users, Intermittent Users, High Chance of Pregnancy* women or *Stable Users*. Brew et al. found similar results in their sequence analysis of 18 and 19-year-old women's relationship, sex, and contraceptive trajectories pooled over person-weeks.[44] Six clusters were identified in Brew et al.'s analysis comparing sequences of behavior across women by grouping similar sequences of young women's relationship, sex, and contraceptive behavior. The predominant clusters were "no relationship" (27%) and not having sex, and in a non-coresidential relationship with no sex (15.8%), which corresponds to the high percentage of teens and 18-22 year old group in our sample who were in the *Single Abstinent* class. The remaining clusters in Brew et al.'s sample were having sex with their partners, while some women used effective contraception (condom use, pill, patch, ring, injection, implant or IUD) and the others used less effective methods (diaphragm, spermicide, withdrawal or rhythm) or no method at all. In our sample, the 13-17 and 18-22 women that were having sex were *Intermittent Users*, *Condom Users*, *Method Switchers*, *High Chance of Pregnancy*. These classes correspond with Brew et al.'s clusters describing groups of teens who frequently transition in both sexual relationships and using contraceptives, and teens who rely on less effective methods in sexual relationships. Brew et al.'s other clusters that describe teens who have sex while using contraception effectively corresponds with the young women from our sample who were *Stable Users*. Both our study and Brew et al.'s results may help explain how, although teens have the highest rate of unintended pregnancies compared to older women, these pregnancies arise from a small subset of sexually active teens that are not using effective forms of contraception.[50]

Research has broadly demonstrated that demographics can have associations with contraceptive behavior, on average, and our studies corroborate some of those findings. In our national sample, Black women had increased risk of being *Single Abstinent* women, *Intermittent Users*, and *Condom Users*, classes where the majority of women rely on least effective methods or primarily use no method of contraception compared with *Stable Users*. Other research studies show that some racial and ethnic minority women have higher rates of contraceptive nonuse and failure, compared to White women.[19,51] Black and Hispanic women are more likely to use Depo-Provera (the shot or injectables) and condoms, while white women are more likely to use oral contraceptives.[1] These differences in racial/ethnic contraceptive behavior may be due to preferences and views surrounding family planning. Prior research has found that non-Hispanic Black, Latinas, and Asian Pacific Islander women were more likely to report preferences for contraceptive methods they are able to stop using at any time, only using the method at intercourse, and the method not changing menstrual periods.[52] These preferences match with lower efficacy methods and may explain some of the differences in contraceptive use classes among racial and ethnic groups.

Across the classes, women with increased incomes, compared to the <138% FPL reference group, were less likely to be in all 6 comparison classes than *Stable Users*. Many research studies have found that contraceptive nonuse and inconsistent use are higher among women with lower income and among women who use publicly funded health insurance or do not have health insurance.[20,33,53-57]

This research study contributes to the understanding of women's individual contraceptive use dynamics. Our results describe intricate contraceptive typologies and how common those behavior patterns are in the US beyond what other literature has been able to glean from cross-

sectional analysis. Future studies examining these behaviors over longer periods of women's lives are needed. Studies that examine the underlying mechanisms of these behaviors, such as contraceptive and childbearing intentions, would inform our understanding of US contraceptive behavior and successful family planning programs.

Limitations

This analysis has several limitations. First, all contraceptive methods in the original NSFG dataset were not used to describe most frequent variable type and method switching. There are too many method types (24 contraceptive methods) to easily compute and interpret the results. Method grouping implies that transitions within one category are less meaningful than transitions between categories. For example, transitioning from pill use to injectables is less meaningful than pill use to inserting an implant.

Another limitation within this analysis involves the underreporting of induced and spontaneous abortions within the data set. Although the NSFG is the most comprehensive source of information on pregnancy and contraceptive use among reproductive-aged women in the United States, abortion underreporting is a major issue.[58] Abortion underreporting will introduce measurement error in some of the derived variables for the latent class analysis including use and types of contraceptive methods during each month. For example, if someone became pregnant during a specific time period and did not report it because they had an abortion, they might not record a discontinuation of a method which would bias a number of variables in this analysis including inconsistent method use (risk of pregnancy), type of method used during that study year, etc. This type of measurement error should have a small effect on the latent class analysis because the percentage of months of data that would be affected by mis-reporting will be small relative to the total number of months of use in the sample.

Finally, another limitation within this study analysis are the time-invariant variables "Federal Poverty Level," and "Education." These responses were gathered at the interview date, and therefore do not reflect the prior three years of the respondents' life. However, published US economic literature shows that on average, poverty level does not fluctuate often between the categories of this variable, especially over a short and recent three-year period.[59,60] For the few respondents who did transition to another FPL category, this analysis could potentially be biased. Similarly, although education level might increase across the three study years, especially for the younger NSFG participants, education level was treated as a time invariant variable because of the small number of participants who may have increased in education level in this short time frame.

Conclusions

This is the first study to use person-centered methodology to examine patterns of individual contraceptive and reproductive behavior using one-year calendar data in a national sample of US women. In a calendar year, women displayed qualitatively distinct patterns of contraceptive behavior as defined by a number of diverse and informative characteristics. These findings indicate that women's contraceptive behavior is not accurately described by one-dimension of method use. It is important to recognize the heterogeneity of experiences among women's contraceptive and reproductive health behaviors. The findings have important public health implications. Some women are deliberate in their approach to family planning, while others exhibit a highly variable profile. Uncovering these latent typologies contributes to the understanding of certain risk profiles and their distribution in the US – women who do not wish to become pregnant, but for whatever reason do not have access to or use a method of

contraception that fits their needs and preferences. The study of contraceptive behavior subgroups contributes to the evidence-base of reproductive health research, with the ultimate goal of informing quality family planning services focused on women's lived experiences.

Tables

Table 1. Distribution of Respondents by Constructed Latent Class Variables for Calendar Year 1, NSFG 2015-2017, n=5539

	Calendar Year 1	
	N	%
Most Frequent Type of Method Used		
Most Effective	1218	22.0%
Moderately Effective	997	18.0%
Least Effective	822	14.8%
No Method	2502	45.2%
Condom Use Frequency (months)		
0	4331	78.2%
1	157	2.8%
2	141	2.6%
3	93	1.7%
4	80	1.4%
5	58	1.1%
6	59	1.1%
7	46	0.8%
8	41	0.7%
9	44	0.8%
10	44	0.8%
11	26	0.5%
12	419	7.6%
Emergency Contraception Use (months)		
0	5480	98.9%
1+	59	1.1%
Sexual Activity (months)		
0	1642	29.6%
1	137	2.5%
2	123	2.2%
3	105	1.9%
4	125	2.3%
5	96	1.7%
6	113	2.0%
7	123	2.2%
8	118	2.1%
9	119	2.2%
10	149	2.7%

11	104	1.9%
12	2585	46.7%
Inconsistent Contraception Use (months)		
0	4484	81.0%
1	98	1.8%
2	75	1.4%
3	61	1.1%
4	59	1.1%
5	57	1.0%
6	56	1.0%
7	49	0.9%
8	48	0.9%
9	63	1.1%
10	50	0.9%
11	50	0.9%
12	389	7.0%
Frequency of Method Type Switches		
0	4338	78.3%
1	711	12.8%
2+	490	8.9%
Marital Status		
Single, Never Married	3230	58.3%
Married	1560	28.2%
Single, Previously Married	535	9.7%
Married Within Year	136	2.5%
Marriage Dissolution Within Year	78	1.4%
Parity		
0	2738	49.4%
1	1069	19.3%
2	954	17.2%
3+	778	14.1%
Total	5539	100%

Table 2. Social and Demographic Characteristics of Study Participants, NSFG 2015-2017, n=5539

	N (n=5539)	%
Age		
13-17	1157	21.0%
18-22	879	15.9%
23-27	915	16.5%
28-32	852	15.4%
33-37	667	12.0%
38-42	657	11.9%
42-47	412	7.4%
Education		
Less than High School	1309	23.6%
High School Graduate	1251	22.6%
Some College	1462	26.4%
College Degree or More	1517	27.4%
Race and Ethnicity		
White Non-Hispanic	2667	48.2%
Black Non-Hispanic	1333	24.1%
Hispanic	1070	19.3%
Other	469	8.5%
Federal Poverty Level		
≤138% of FPL	2089	37.7%
139% to 199% of FPL	823	14.9%
200% to 299% of FPL	850	15.4%
300% to 399% of FPL	541	9.8%
≥400% of FPL	1236	22.3%
Religion		
No Religion	1258	22.7%
Catholic	1104	19.9%
Protestant	2716	49.0%
Other Religions	461	8.3%
Total	5539	100%

Table 3. Goodness of Fit Indices for Model Selection (NSFG, 2015-2017; n=5539)

Number of Latent Classes	Number of Parameters Estimated	Log-likelihood	AIC	BIC	SSABIC	LMR-LTR (*p*)	Entropy
2	33	-63380.496	126826.992	127045.438	126940.574	N/A	0.983
3	50	-52404.185	104908.370	105239.349	105080.464	21464.278 (<0.001)	0.984
4	67	-44706.804	89547.608	89991.119	89778.214	17682.785 (<0.001)	0.984
5	84	-43010.246	86188.492	86744.536	86477.610	3370.117 (<0.001)	0.977
6	101	-42227.670	84657.340	85325.917	85004.970	1554.543 (<0.001)	0.974
7	118	**-41693.857**	**83623.714**	**84404.823**	**84029.855**	1060.390 (<0.001)	0.965
8	Best log-likelihood not replicated						

Table 4. Contraceptive Behavior Dynamics by Class Membership: Probabilities and Means of Class Indicators among Single Mothers, Intermittent Users, Single Consistent Users, Stable Users, Method Switchers, Condom Users, and High-Risk Pregnancy Classes; NSFG, 2015-2017; n=5539

	7 Class Model						
	Single Abstinent Women	**High Risk of Pregnancy**	**Intermittent Users**	**Single Mothers**	**Method Switchers**	**Condom Users**	**Stable Users**
Latent Class Prevalence	*0.25*	*0.12*	*0.08*	*0.06*	*0.05*	*0.13*	*0.31*
Probability							
Most Frequent Method							
Most Effective Method	0.01	0.00	0.08	0.51	0.17	0.04	0.54
Moderately Effective Method	0.10	0.00	0.28	0.06	0.24	0.18	0.30
Least Effective Method	0.00	0.00	0.04	0.00	0.22	0.78	0.12
No Method	0.89	1.00	0.60	0.43	0.37	0.00	0.04
Emergency Contraception Use							
No	1.00	1.00	0.95	1.00	0.97	0.97	1.00
Yes	0.00	0.00	0.05	0.00	0.03	0.03	0.00
Switching							
0	0.95	0.79	0.24	0.94	0.00	0.66	0.95
1	0.05	0.17	0.29	0.05	0.64	0.18	0.04
2+	0.00	0.04	0.47	0.01	0.36	0.16	0.01
Parity							
0	0.96	0.33	0.68	0.08	0.34	0.49	0.24
1	0.04	0.33	0.17	0.33	0.32	0.20	0.22
2	0.00	0.19	0.10	0.27	0.22	0.20	0.28
3+	0.00	0.14	0.05	0.32	0.12	0.11	0.26
Marital Status							
Single, Never Married	0.97	0.37	0.80	0.29	0.48	0.62	0.36
Married	0.01	0.48	0.07	0.17	0.42	0.26	0.49
Single, Previously Married	0.02	0.08	0.08	0.47	0.05	0.09	0.11
Married within Year	0.00	0.05	0.03	0.01	0.05	0.02	0.03
Dissolution within Year	0.00	0.02	0.02	0.06	0.01	0.01	0.01

Mean (in Months)							
Condom Use	0.00	0.01	1.80	0.01	1.70	10.20	0.01
Inconsistent Use	0.00	10.30	0.20	0.07	4.40	0.07	0.00
Sex	0.01	10.90	3.50	0.30	10.50	10.80	11.30

Table 5. Predicted Probabilities from Multinomial Logistic Regressions Examining Predictors of Latent Class Membership; NSFG, 2015-2017; n=5539

	Single Abstinent Women	High Risk of Pregnancy	Intermittent Users	Single Mothers	Method Switchers	Condom Users	Stable Users
Latent Class Prevalence	*0.25*	*0.12*	*0.08*	*0.06*	*0.05*	*0.13*	*0.31*
Age							
13-17	0.79	0.01	0.10	0.00	0.01	0.05	0.03
18-22	0.22	0.13	0.14	0.01	0.09	0.18	0.23
23-27	0.11	0.16	0.06	0.03	0.10	0.20	0.33
28-32	0.07	0.18	0.05	0.05	0.08	0.16	0.40
33-37	0.07	0.16	0.04	0.08	0.04	0.14	0.47
38-42	0.09	0.12	0.02	0.15	0.03	0.10	0.49
43-47	0.07	0.12	0.02	0.22	0.01	0.07	0.50
Education							
Less than High School	0.14	0.18	0.03	0.03	0.06	0.12	0.45
High School Graduate	0.08	0.17	0.05	0.03	0.04	0.14	0.48
Some College	0.09	0.14	0.07	0.03	0.05	0.18	0.43
College Degree+	0.21	0.12	0.11	0.02	0.05	0.17	0.33
Race and Ethnicity							
White Non-Hispanic	0.12	0.15	0.05	0.03	0.05	0.14	0.47

Black Non-Hispanic	0.14	0.15	0.08	0.03	0.04	0.17	0.39
Hispanic	0.10	0.14	0.06	0.03	0.05	0.16	0.47
Other	0.15	0.18	0.05	0.03	0.06	0.14	0.39
Federal Poverty Level							
≤138% of FPL	0.12	0.17	0.06	0.05	0.06	0.16	0.38
139% to 199% of FPL	0.15	0.16	0.06	0.03	0.05	0.15	0.41
200% to 299% of FPL	0.12	0.15	0.06	0.04	0.06	0.14	0.42
300% to 399% of FPL	0.13	0.13	0.04	0.03	0.05	0.17	0.46
≥400% of FPL	0.11	0.15	0.06	0.01	0.03	0.15	0.47
Religion							
No Religion	0.12	0.15	0.07	0.03	0.04	0.17	0.43
Catholic	0.12	0.17	0.05	0.02	0.05	0.14	0.45
Protestant	0.11	0.18	0.05	0.04	0.05	0.14	0.44
Other Religions	0.16	0.12	0.05	0.03	0.06	0.17	0.40

CHAPTER 3: CONTRACEPTIVE BEHAVIOR DYNAMICS AND UNINTENDED PREGNANCY: A LATENT TRANSITION ANALYSIS

Introduction

The long-standing public health measure of unintended pregnancy is defined as a pregnancy that occurred when a woman wanted to become pregnant in the future but not at the time she became pregnant, or one that occurred when she did not want to become pregnant then or at any time in the future. The most recent analyses find that in 2011, there were 98 pregnancies for every 1,000 women aged 15-44 in the United States and 45 of those pregnancies were unintended [5]. Reducing the national level of unintended pregnancy is one of the most important health goals identified by the US Department of Health and Human Services. [61] Unintended pregnancy is statistically associated with poor health outcomes for some women, including inadequate or delayed initiation into prenatal care, premature and low-birth weight infants, and increased risk for physical and mental health problems for women and their children.[62,63] The concept of unintended pregnancy serves as a proxy measurement to help public health institutions understand the unmet need for contraception services across the United States. Such large numbers of women experiencing unintended pregnancy is a strong signal that US women are still unable to achieve reproductive autonomy. However, the measure of unintended pregnancies is an inadequate indicator of women's lived experiences. Examining this measure alone cannot capture the complexities of women's experiences prior to having an unintended pregnancy, the context in which the pregnancy occurs, or what happens to an individual woman after she experiences a pregnancy she did not want.[64]

Individual reproductive health trajectories are rarely measured longitudinally; although new research studies have identified certain behavior profiles that characterize women's dynamic contraceptive and reproductive health experiences in certain age groups or populations.[44,45] The results from these studies show heterogeneity in contraceptive trajectories across women of reproductive age and throughout the world. Still, critical dimensions of pregnancy risk and contraceptive behavior are unexplored across the larger US population.

The current study uses latent transition analysis (LTA) to estimate longitudinal patterns of contraceptive behavior, sexual activity, and life stage, and probability of transitioning between typical behavior patterns over a three-year period. Instead of directly measuring a single observed variable such as contraceptive method type, LTA allows us to capture additional nuance by classifying distinct subgroups of women's multifaceted contraceptive behavior using a measurement model – latent class analysis – across time. In the present study, we use a population-based, national sample of US women to explore the distinct subgroups of women's contraceptive behavior across a three-year period, quantify the change between latent subgroups over time, examine how sociodemographic variables are associated with latent groups, and finally, explore how pregnancy experiences affect individual change in contraceptive behavior.

Background

In the United States, there are around 74.7 million women of reproductive age (15 to 49 years old). More than 99% of women aged 15-44 who have ever had sexual intercourse have used at least one method of contraceptive in their lifetimes [28] and around 60% of reproductive-aged US women are currently using a contraceptive method.[65] Even though most women in the United States will use some form of contraception at some point in their lifetime, and a majority of the population is using contraception at any given point in time, many women in the United States struggle to avoid pregnancies they do not want or successfully time and space wanted

pregnancies.[2] A long-standing public health measure, unintended pregnancy, describes a pregnancy that occurs at the wrong time or when a woman did not want to become pregnant then or at any time in the future. This conventional measure does not capture the complexities of women and couples' lived experiences; nevertheless, when asked, many women in the United States confirm that they did not intend to become pregnant at the time they conceived [66]. The United States also has significantly higher rates of unintended pregnancy than other developed countries.[5-7]

A little less than half (45%) of all pregnancies in the United States were unintended in 2011, and many unintended pregnancies occur among women who either use contraceptive methods incorrectly, inconsistently, or use no method at all, with the remaining 5% a result of contraceptive failure.[2,8] Unintended pregnancy is statistically associated with poor health outcomes for some women, including inadequate or delayed initiation into prenatal care, premature and low-birth weight infants, and increased risk for physical and mental health problems for women and their children.[62,63] Unintended pregnancy may also cause women to forgo personal, professional, and education goals. [67] Unintended pregnancy disproportionately affects low-income women (women with incomes less than 200% of the federal poverty level), women aged 18-24, cohabiting women and women of color in the United States.[5,12,13] Unintended pregnancy rates are lowest among higher-income women, white women, college graduates, and married women.

Family planning services undeniably help women avoid pregnancies they do not want and plan pregnancies they do want. Many studies show that contraception is one of the most cost-effective programs in existence.[68] In 2014 alone, these services helped US women avoid two million unintended pregnancies.[69] But the relationship between contraceptive use and

pregnancy intention is complex.[70-72] At any given time, a woman's contraceptive use depends upon the internal balance between positive and negative feelings towards getting pregnant and her positive and negative feelings about a current contraceptive method.[73] Using a national sample of women aged 18-39, Jones (2015) contrasted the effects of two measures of pregnancy attitudes – current importance of avoidance of pregnancy (pregnancy avoidance) and unhappiness at the thought of being pregnant (pregnancy feelings) – on consistent contraceptive use over time. Only pregnancy avoidance was associated with consistent contraception use.[74]

Rates of unintended pregnancy among girls and women 15-44 years of age in the United States declined by 18% from 2008 to 2011.[5] There is some evidence showing that the increase of highly effective long-acting contraceptive method use in recent years, such as intrauterine devices (IUDs) and implants, has contributed to the decline in the rate of unintended pregnancy.[15,16] However, Kavanaugh et al. found that the increase in the use of IUDs and implants is not associated with a decrease in nonuse of contraception – so the majority of increase in these methods is attributed to women who were already using some form of contraceptive and who switched to highly effective methods.[17] Similarly, a 2019 study found that among privately insured women in Pennsylvania, new long-acting reversible contraceptive (LARC) use was associated with women who were already using prescription methods.[75] Identifying the longitudinal trajectories of women who are switching from a less effective to a highly effective method is an important investigation as this behavior has effectively reduced the unintended pregnancy rate at the US population level.

Gap in Literature on Longitudinal, Individual Patterns of Reproductive Health

The average US woman wants to have about two children; to do so, she will spend about three years pregnant, postpartum, or trying to become pregnant, and about three decades trying to avoid pregnancy.[2,76] However, very few research studies examine individual patterns of

contraceptive use over time because longitudinal patterns can be very difficult to study. For example, an individual's contraceptive use is initiated through a multivariable decision process. Some methods to prevent pregnancy can be used for minutes, while others last decades. Then, this process is repeated again at subsequent life stages. This behavior also interacts with the fluctuating pregnancy intentions, parity, and socioeconomic forces across time. Contraceptive attitudes also evolve. A woman's contraceptive needs and expectations change as she progresses through the life course. It is important to consider and appreciate the complexity of individual contraceptive use behavior and how it can change over time.

A growing number of recent studies have used longitudinal data to examine contraceptive behavior from a person-centered perspective. The Relationship Dynamic and Social Life study is a panel study of young women aged 18 to 19 from Michigan that followed 992 women with weekly surveys for two and a half years. Brew et. al applied sequence analysis to 581 women in this sample and identified six trajectories of joint relationship, sex, and contraceptive typologies. In a different five-year, retrospective study from the Demographic and Health Survey Analytic Studies, the authors found several profiles based on contraceptive use and pregnancy experiences in large samples of women aged 15-49 from Burundi and Nepal.[45] Looking at the five-year sequence patterns, the authors used cluster analysis to define contraceptive profiles based on contraception and pregnancy status. They found six distinct subgroups of women's reproductive behavior in these two countries, including Modern Mothers who adopt short-term modern methods such as birth control pills, Consistently Covered Mothers who use long-acting methods, and Family Builders and Quiet Calendar both of whom do not use contraception, and either become pregnant multiple times (Family Builders) or do not (Quiet Calendar).[45] Both of these studies used novel methodology to highlight the heterogeneity of contraceptive use behavior and

reproductive experiences over time. Brew et al. 2020 focused on young adult experiences over one year in a Michigan county while MacQuerie et al. captured a single contraceptive state through the five years of calendar data in women from Burundi and Nepal.

Reproductive Life Course

Typically, dynamic contraceptive use behavior is reported using age as a proxy for reproductive life course. There are certainly different patterns of contraceptive use found across age groups. For example, oral contraception use decreases with increasing age, whereas female sterilization increases with increasing age.[1] Other studies find that stable contraceptive use, defined as use of contraception at some point during every at-risk month and last sexual intercourse, is highest for teens and then decreases across age groups.[34] But the main reason for an individual's use of contraception is to avoid pregnancy and control the occurrence of a major life event (i.e., having a child).[77] While age is an essential and useful life course measure for understanding contraceptive behavior, individual trajectories of reproductive behavior are not linear and do not necessarily follow age-based paths. The life course approach is a useful lens through which to investigate trajectories of contraceptive use as it emphasizes individual histories, time, and the impact of relationships.[78] This study aims to expand previous research by adding important reproductive life stage contexts to women's contraceptive profiles, including parity and marital status, as life stage markers, as well as constructs describing the consistency of contraceptive use behavior. The objectives of this chapter are to characterize change in contraceptive behavior typologies over time, describe how social and demographic characteristic are associated with those behaviors, and examine how individual change in contraceptive behavior is affected by a pregnancy experience.

Methods

Participants

Data for this analysis come from the most recent round of the National Survey of Family Growth conducted in 2015-2017.[46] The NSFG is conducted in home with face-to-face interviews of men and women aged 15-49 years. In total, 5,554 women and 4,540 men were interviewed in the 2015-2017 data collection round.

Measures

The NSFG does not follow the same women over time; however, the NSFG has a longitudinal component: the contraceptive calendar. The NSFG's contraceptive calendar captures contraceptive method(s) female respondents used each month for the time period from the January three years prior to the interview date, through the interview date. For example, for interviews done in October 2017, the contraceptive calendar data collects monthly information from January 2014 through October 2017. The first three years of contraceptive calendar data were used in this analysis, excluding the interview year, in order to standardize the amount of time in the survey for each woman. If a woman was interviewed in January, she would only have one month of data for the interview year while a woman interviewed in October would have 10 months of interview year data. So, for the participant who was interviewed in October 2017, this study would capture her contraceptive behavior from January 2014 to December of 2016.

Six contraceptive behavior indicators were created for years 1, 2 and 3 of the NSFG calendar data to describe contraceptive behavior typologies (Table 6). In the calendar, women were able to report up to four methods of contraception used during each month and sexual activity with an opposite sex partner in that month. Two life course variables – marital status and parity– were also included in our analysis using data from the larger NSFG survey and constructed to reflect the status of these variables during each calendar year of the three-year

period. The NSFG does not distinguish pregnancy months in the calendar data. Therefore, women at various stages of pregnancy throughout the three-year period will be characterized based on other indicators.

Most Frequent Type of Method. Participants were able to report up to four methods of contraception used in each calendar month. Using the primary method reported in each month, methods were grouped into four categories of effectiveness:

1. Most effective (sterilizations and vasectomy, IUDs, coil, loop, and hormonal implants)
2. Moderately effective (birth control pills, Depo-Provera, contraceptive patch, and vaginal contraceptive ring)
3. Least effective (barrier methods – female and male condoms, withdrawal, foam, jelly, suppositories, diaphragms and caps, jelly, and natural family planning – calendar rhythm, standard days or cycle beads, and safe periods)
4. No method

Condom Use Frequency. The number of months the participant used condoms during each year. This variable uses all four mentions of contraceptive method types that a woman could document over the course of one month. For example, if a respondent said she used the pill as her first method, and then said she used condoms as the second method mentioned, condom use would be reported within that study month for that participant. This variable was recorded as 0 to 12 months of condom use during each year.

Emergency Contraception Frequency. The number of months the participant used emergency contraception (EC) during each year. This variable uses all 4 mentions of contraceptive method types that a woman could document over the course of one month. For example, if a respondent said she used withdrawal as her first method, and then said she used

emergency contraception as the second method mentioned, emergency contraception use would be reported within that study month for that participant. This variable is categorized as 0 for no EC use during the calendar year and 1 for any EC use during each year.

Sexual Activity Frequency. The number of months the participant was sexually active with an opposite sex partner during each year. The NSFG asks about any occurrence of sexual intercourse during that month and does not distinguish vaginal intercourse from other forms of sexual intercourse. This variable is categorized as 0 to 12 months of sexual activity during each year.

Inconsistent Contraception Use. The number of months a participant was sexually active and simultaneously not using a method of contraception within each study year. This variable will include months in which women were pregnant or trying to become pregnant. This variable is categorized as 0 to 12 months of inconsistent contraceptive use during each year.

Frequency of Contraceptive Method Switching. The frequency of switching method types, based on the four categories of contraception described above. Since there are 12 months in a year, a participant may switch contraception methods up to 11 times in one study year. Switching is collapsed to 0, 1, 2 or more contraceptive method changes during each study year.

Marital Status. Participants' marital status during each calendar year. A woman could be categorized as "single in the study year, never been married, "single in the study year, had a previous marriage," "married throughout the year," and, in order to indicate a relationship transition period within the study year , "got married in the study year," and "had a marriage dissolution[3] in each year." A participant might have multiple marriage events in a study year (e.g., got married and had a marriage dissolution in the study year). The participant is

[3] Marriage dissolution may include divorce or spousal death.

categorized by the last event that occurred in that year. For example, if she entered the study year married, divorced within the year, and remarried in the year then she would be categorized as "got married in the year."

Parity. Parity is measured by total number of pregnancies that ended in live births. Parity during each year was constructed by subtracting the number of live births since the start of each calendar year from the parity at the time of the interview. This variable is categorized as 0, 1, 2 or 3+ live births.

Covariates (Predictors of Statuses and Transitions)

Six additional categorical variables were used as covariates to predict latent status membership or transitions (Table 7). These were: age, education, race/ethnicity, federal poverty level, religion, and pregnancies within study years 1 and 2; these variables are described below and shown in Table 7.

Predictors of Statuses at Calendar Year 1

Age. Age in each year of contraceptive calendar data is approximated by respondents' age at the time of interview minus three, two, and one years, respectively, for each study year. Age range of participants is 13-49 across all three study years.

Education. Education is measured using the highest education level achieved by the respondent, measured at the time of the interview. We also include a variable to indicate whether the respondent is a student in each of the study years.

Race and Ethnicity. Race was measured in the screener questionnaire of the NSFG. Responses include White, Black or African American, Hispanic, and Other race groups. The public use data file reports a collapsed race variable to minimize risk of inadvertent disclosure. Other race includes American Indian or Alaska Native, Asian Indian, Chinese, Filipino,

Japanese, Korean, Vietnamese or Other Asian, Native Hawaiian, Guamanian or Chamorro, Samoan or Other Pacific Islander.

Religion. Religion is measured by current religious affiliation including no religion, Catholic, Protestant, or "Other" religions. "Other" is a collapsed response of many different types of other religions including Jehovah's witness, Muslim, Buddhist, United Pentecostal Church, Greek Orthodox, etc.

Federal Poverty Level. Poverty level of the respondent's family income is measured by percent of the Federal Poverty Level (FPL). This variable ranges from 5% to >500%.

Predictors of Transitions

Pregnancies

A pregnancy intention variable was constructed from responses to questions on whether a woman wanted to get pregnant just before each pregnancy reported in the calendar occurred. This is the most direct measure available of the extent to which women are able (or unable) to choose to have the number of births they want, when they want. If a woman reported a pregnancy in the questionnaire, she was asked about the wantedness of that pregnancy. The response options included right time, too soon or mistimed, later or overdue, didn't care or indifferent, unwanted, and don't know or not sure. For the purposes of this analysis, a constructed pregnancy intention measure was categorized for each reported pregnancy dichotomizing "unintended" or not. *Unintended* pregnancies included pregnancies that occurred too soon or mistimed, unwanted, didn't care or indifferent, and "don't know" or "not sure" pregnancies. All other pregnancies included pregnancies that occurred at the right time, later or overdue.

Latent Transition Analysis

This research study uses latent transition analysis (LTA) to model change in women's self-reported contraceptive behavior in a national sample of US women over the course of three calendar years. Latent transition analysis describes a type of longitudinal autoregressive model common in social science research where the outcome variable is a latent categorical variable. The latent construct is captured using a measurement model, which is most commonly a latent class analysis model. The LTA model describes change in outcomes where the outcomes are not directly observed. That is, the outcomes in LTA models are latent and are indicated by a set of observed variables. LTA is particularly relevant to study the longitudinal trajectories of contraceptive behavior. First, LTA is a person-centered model-based approach that identifies classes of women based on multiple aspects of individual contraceptive behavior, sexual activity, and life stage. Second, LTA addresses change over time and the extent to which other variables are related to that change. With LTA, change is discontinuous and individuals move through discrete categories or stages.

In Chapter 2, latent class analysis empirically explored groups of women based on their one-year contraceptive behavior dynamics. These classes were identified and validated. In this analysis, LTA is used to identify longitudinal patterns and transitions across classes throughout all three years of the 2015-2017 NSFG contraceptive calendar. Six demographic and reproductive health covariates were then added to model the transition probabilities. Figure 1 shows the specific LTA conceptual model for this analysis. The inclusion of sociodemographic covariates in the LTA model can describe diversity in the process being studied.

Model Estimation

All models were analyzed using the statistical software Mplus 8.4, based on Ryoo et al. (2018) and Nylund (2007).[79,80] Stata 16.0 (StataCorp, College Station, TX) was used for data

management and analytic sample creation while Mplus 8.4 (Muthén and Muthén, 2019) was used for analyses.

LTA Model Specification and Analysis

The first step in fitting and evaluating LTA models is to explore the measurement models at each time point of our analysis in order to inform the number of latent statuses in the longitudinal model. We use latent class analysis (LCA) models across each of the three calendar years. LCA is a measurement model in which individuals can be classified into mutually exclusive and exhaustive types, or latent classes, based on their patterns of answers on a set of indicator variables. In this case, there were eight indicators of contraceptive behavior, sexual activity, and life stage. Covariates were not considered in this part of the analysis.

The starting point for conducting an LCA on empirical data is a contingency table formed by cross-tabulating all the observed indicator variables. A latent class model is then made up of the estimated latent class prevalences and item-response probabilities that can be used to obtained expected cell proportions for this contingency table. This was done for each study year. Latent transition analysis then allows us to characterize change between latent classes across time. For example, if an individual is in a particular latent class at study year 1, what is the probability that the individual will be in that latent class at study year 2, and what is the probability that this individual will be in a different class? The probability of membership in latent class s at Time t is a function of the probabilities of membership in each latent class at Time $t - 1$ and the conditional probability of transiting from each latent class into latent class s between Time $t - 1$ and Time t. In order to interpret this change over time, measurement invariance, or constraining the item-response probabilities in LTA to be equal across times, is an important assumption. Measurement invariance assumes the equality of the parameters of the measurement model, specifically the item probabilities for LCA variables conditional on class

membership. Assuming full measurement invariance facilitates straightforward discussions about transitions among the classes because the classes are always the same across the three-year period. While measurement invariance implies that the structure of the classes is the same across time, it does not impose any restrictions on the size of the class. Formal measurement invariance testing in the form of likelihood ratio tests (LRTs) is used to assess statistically the plausibility of measurement invariance. By comparing the measurement invariance and measurement variance model, the best candidate model is chosen with the goal of achieving measurement invariance so the characteristics of the latent statuses can be interpreted in the same way across time. We expect measurement invariance in this model. Measurement may vary by an individual woman's age; however, there is much less reason to suspect that measurement would vary from year to year in any meaningful way given that the women in our sample are heterogenous with respect to age within any given year. After latent statuses were defined, we also formally tested the transition probability invariance from year 1 to year 2 to year 3. We do not expect there to be a difference in transitions from one typical calendar year to the next (i.e., we expect to impose transition invariance from Time 1 to Time 2 and Time 2 to Time 3).

Lastly, we incorporate demographic covariates – age, education, race and ethnicity, federal poverty level, and religion – as correlates of latent statuses at study year 1 using a multinomial logistic regression model. We also used a multinomial logistic regression model to explore how pregnancy experience in study year 1 affects transition probabilities from years 1 to 2 and how pregnancies in year 2 affect transition probabilities from years 2 to year 3.

Sensitivity Analyses

Two sensitivity analyses were run to validate this model. First, to attempt to capture the contraceptive behavior of women who were not pregnant in any given study year, women who

reported a pregnancy ending in any study year (n=1210) were excluded from the original sample to yield a final sensitivity analysis sample of n=4329. The LTA modeling process was repeated without these women in order to capture the contraceptive behavior typologies of women who were not pregnant during the study time period. Second, in the original model, two life stage variables – parity and marital status – were included to demonstrate how relationship dynamics and reproductive status evolve together with contraceptive behavior. Although we do consider these variables to provide valuable insight into the ways in which women use contraception over time, we conducted a sensitivity analyses that specifically focuses on behaviors and excludes these life stage variables. In this model, six variables – most frequent method of contraception, inconsistent use, condom use, emergency contraception use, sexual activity, method switching – were used to form the latent class and latent transition model.

Results

As shown in Table 8, the 7 class solution models were favored with respect to the fit indices for all three time periods. The AIC, BIC, and adjusted BIC all favored the 7-solution model. The entropy of the models is reported in Table 8 but not used for model fit because it is a measure that describes the overall classification of women into the latent classes assuming the model is correct. [81] We also considered the 6-solution models in order to explore the fit of a slightly simpler and more parsimonious model. Given the study design, longitudinal measurement invariance was imposed in order to interpret the observed items over the latent statuses through the three time points.

Although the fit statistics indicate a seven-solution model is preferred, we also explored a more parsimonious six-solution model. We examined the profiles of the six-solution and seven-solution models based on status prevalences and item response probabilities and means. The seven-solution model resulted in a very small, and therefore potentially unstable, class with a

prevalence of 0.03 in Time 1. But when we examined the six-solution model results, this small class was still present and other classes were being combined when moving from a seven-class model to a six-class model. We decided to select the more complicated, yet more nuanced, seven-solution model. Table 9 shows the results of the 7-solution models latent statuses with item probabilities and means for each latent status. See the Appendix 7 for the results of the 6-solution model.

Based on the item probabilities, we classified the seven different groups of women as: *Single Abstinent Users,* (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7). Table 5 describes the probabilities and means for each latent status. The first latent status was characterized by abstinence (L1). They had the lowest mean (0.0) of sexual activity of all seven statuses. Most of these women were single never married (85%), had 0 children (80%), and used no method of contraception (81%). *Stable Users* (LS2) were identified by their high level of consistent sexual activity, but low probability of having unprotected sex throughout the study period. They used a range of contraceptive methods, 51% used moderately effective methods, while 21% used the most effective and 16% used least effective methods.

The next status, *Consistently Covered Mothers* (LS3), looked similar to *Stable Users* in terms of high mean months of sexual activity and low levels of unprotected sex. However, 100% of these women had a least one child and 82% of these women were using the most effective methods of contraception. This latent status consisted of mostly married women (64%) or previously married women (17%), but a small number (15%) were single, never married. The fourth latent status, *High Chance of Pregnancy* women, is comprised of women who have a high probability of becoming pregnant in any given study year. They consistently have unprotected

sex, more than any other latent status group. Over 70% of this group use no method of contraception and do not switch methods (71%). This status includes women who were already pregnant or postpartum, trying to become pregnant, as well as those women who had unprotected sex and did not want to become pregnant. 50% are married and 36% are single, never married. *Condom Users* comprised the fifth latent status, as they had the highest mean months of condom use, almost equal to their mean months of sexual activity with low levels of unprotected sexual activity. Half of the women in this group have no children and 62% are single, never married.

The sixth latent status, *Intermittent Users,* which is comprised of 75% single, unmarried women, is characterized by their low means of sexual activity over each year, but low levels of unprotected sex. Even though most of these women are using no method for the majority of the year (68%), women in this status are not having frequent sex and rarely exhibit inconsistent contraceptive use behavior and so they are defined as *Intermittent Users.* 5% of *Intermittent Users* used emergency contraception in the past year. Finally, the last latent status comprises *Unstable Users*, as most of these women are switching contraceptive methods at least once throughout the year. They have sex frequently, and about half the time are having unprotected sex. The majority use least effective methods (48%) throughout the year or no method (39%) and also have the highest probability of using emergency contraception (7%) of any latent status.

Table 10 summarizes the latent status prevalence and the transitions over the three time points for women's contraceptive behavior. Starting with the δ estimates, we examine the prevalence rates over the three time periods. The prevalence rates indicated that the probability of being in the *Single Abstinent User* (LS1) group was the highest across the time periods but decreased across time; 0.29, at Time 1, 0.26 at Time 2, and 0.23 at Time 3, whereas the probabilities of being in the *Unstable Users* (LS7) was the lowest but increased across time; 0.03

at Time 1, 0.05 at Time 2, and 0.05 at Time 3. Other groups remained relatively consistent in prevalence. The probability of being in *Stable Users* (LS2) was 0.15 at Times 1 and 2, and 0.16 at Time 3, in *Consistently Covered Mothers* (LS3) it was 0.18 across all time points, in *High Probability of Pregnancy Women* (LS4) it was 0.14 at Times 1, 0.15 at Time 2, and 0.17 at Time 3, in *Condom Users* (LS5) it was 0.13 and 0.11 at Times 2 and 3, and finally, in *Intermittent Users* (LS6) it was 0.08 at Time 1, and 0.10 at Times 2 and 3.

We formally tested the transition probability invariance. The results indicated that the BIC and the LRDT favored the transition invariant model, the AIC favored the free transition probability model (See Appendix 6). We had no reason to believe that contraceptive behaviors would change in a different manner from one typical calendar year to another. Thus, we chose the model that restricted change between latent statuses across time.

The second block of Table 10 summarizes the transition matrix. Women in several statuses (*Single Abstinent Users*, *Stable Users*, *Consistently Covered Mothers*, and *High Chance of Pregnancy*) remained relatively stable within their classes from Times 1 to 2 to 3 (transitions probability for remaining in the same class was >0.70). For those *Single Abstinent Women* (LS1), about 12% of them moved into *Intermittent Users* (LS6) status. About 13% percent of women in the *Stable Users* (LS3) status transitioned to *High Chance of Pregnancy* (LS4). Some women in *High Chance of Pregnancy* (LS4) tended to move to *Stable Users* (LS2) (11%). Around 12.1% of *Condom Users* (LS5) transitioned to *Unstable Users* (LS7). The last two statuses transitioned more frequently to other classes across the three study years. *Intermittent Users* (LS6) tended to move to *Single Abstinent Women* (LS1), 15.7%, or *Condom Users* (LS5), 12.6%, although around 46% of *Intermittent Users* remained in that status. For *Unstable Users* (LS7), most of these women tended to move to Stable Users (LS2), 12.0%, *High Chance of Pregnancy* (LS4)

status, 27.5%, or *Condom Users* (LS4), 15.6%. Only a small percentage (32.0%) of women remained in the *Unstable Users* (LS7) status as they transitioned from year to year.

LTA with Covariates

This complex model prohibited adding covariates using a three-step bias correction procedure [49]. However, the final LTA model with seven classes at three time points had a very high entropy of 0.973 which means that the classification probabilities are very close to the true classification. Using the most likely membership variable for each categorical latent variable, a multinomial logistic regression was run using the covariates – age, education, race and ethnicity, education, and religion. Multinomial logistic regressions were also conducted with latent categorical variables on the covariates and pregnancy experiences in order to capture transition probabilities affected by pregnancy experiences. The results of the effect of these variables on status prevalence and transition probabilities are summarized in Tables 11, 12 and 13.

Latent Status 1, *Single Abstinent* women, was the referent class in the multinomial logistic regression model. Compared to *Single Abstinent* women, a one-year increase in age was associated with increased odds of being any of the six other latent classes. A one-unit increase in federal poverty level was also associated with increased odds of being a *Stable User*, and decreased odds of being in *High Chance of Pregnancy*. Black women were less likely to be *Stable Users*, and more likely to be *Condom Users* or *Intermittent Users* than *Single Abstinent* women. Hispanic women had increased odds of being *Stable Users* and *Intermittent Users* while participants who identified as "Other" were less likely to be *Stable Users*. Education level was significant in many contraceptive behavior states compared to *Single Abstinent* women. Graduating from high school or having post-secondary education was associated with increased odds of *Stable Users, Consistently Covered Mothers, High Chance of Pregnancy, Condom Users*, *Intermittent Users*, and *Unstable Users*. Identifying as Protestant was associated with

decreased odds of being in *Stable Users* or *Condom Users* but increased odds of being a *Consistently Covered Mother.* Identifying as "Other" religion was associated with decreased odds of being a *Stable User*, *High Chance of Pregnancy*, *Condom User* and *Intermittent User* compared to *Single Abstinent* women.

The transition probabilities from Tables 12 and 13 compare the change in contraceptive behavior state among women who had unintended and intended pregnancies in study years 1 and 2. Very few women who have pregnancies remain in the same status from year to year, as indicated by each table's diagonal numbers. Women who have intended pregnancies have higher transition probabilities of moving to *High Chance of Pregnancy* status than women who have unintended pregnancies, especially for women who are *High Chance of Pregnancy, Condom Users, Intermittent Users or Stable Users* in the previous year. For *Single Abstinent* women who have unintended pregnancies, 42% and 36% remained *Single Abstinent*, 32% and 26% became *Stable Users* and 18% and 15% become Consistently Covered Mothers, in years 1 and 2, respectively. Women who had an unintended pregnancy in year 1 were more likely to transition to *Stable Users* in year 2 than women who had an intended pregnancy, especially for *Stable Users*, *Consistently Covered Mothers*, *High Chance of Pregnancy Women*, and *Condom Users*. *High Chance of Pregnancy, Condom Users, Intermittent Users. Unstable Users* who had an unintended pregnancy in year 1 were also more likely to transition to *Intermittent Users* in year 2 than women who had an intended pregnancy, although these results are not robust compared to year 3. Additionally, *Single Abstinent, Stable Users*, and *High Chance of Pregnancy* women who had an unintended pregnancy in Year 2 were more likely to transition to *Consistently Covered Mothers* than women who had an intended pregnancy in Year 2.

Sensitivity Analysis

Removing Parity and Marital Status from LCA/LTA

In the original model, two life stage variables – parity and marital status – were included to demonstrate how relationship dynamics and reproductive status evolve together with contraceptive behavior. Although we do consider these variables to provide valuable insight into the ways in which women use contraception over time, we conducted a sensitivity analyses that specifically focuses on behaviors and excludes these life stage variables. In this model, six variables – most frequent method of contraception, inconsistent use, condom use, emergency contraception use, sexual activity, method switching – were used to form the latent class and latent transition model.

Appendix 10 summarizes the results of the latent class analyses at each study year 1, 2, and 3. The fit indices show that a seven-solution model was favored in years 1 and 2, while a nine-solution model was favored in year 3. However, the smallest class in the seven-solution model was less than 5% of the sample, indicating an unstable latent class. Therefore, a six-solution model was considered for the latent transition analysis across all three study years.

In the LCA for study year 1, six classes were identified (Appendix 11). Class 1 is defined by its abstinent women. Class 2 by their condom use, Class 3 by moderate amount of sexual activity, condom use, Class 4 by method switching, Class 5 by their high amount of unprotected sexual activity, and Class 6 by their stable contraceptive use i.e. high amount of sexual activity, low amount of unprotected sex, and use of effective contraceptive methods.

The LTA identified similar statuses across all three study years as the LCA found in study year 1 (although the results in Appendix 12 show a different order). Appendix 13 shows the prevalence and transition probabilities. The abstinent women are a prevalent group across the years but tend to transition to the group with a moderate amount of sexual activity. The group

with a moderate amount of sexual activity tends to switch to abstinent user group or the stable group. The status with a high amount of unprotected sex transition to the stable user group. The method switching class tends to transition to the stable use status, unprotected sex status and the condom users. Some condom users transition to method switchers.

This sensitivity analysis shows a few differences from the original model that includes the reproductive life stage variables parity and marital status. There are several similarities in the two models implying that the classes and statuses were weighted more heavily on the behavior variables even in the original model. For example, both the sensitivity analysis and the LTA model presented in this paper include a large abstinent status, condom use status, consistent user status (labeled "Stable Users" in the original model), status with high amounts of unprotected sexual activity, and status with less frequent amounts of sexual activity (labeled "Intermittent Users" in the original model). The sensitivity analysis model also includes a status that switches methods often, has frequent sexual activity but half the time has unprotected sex, and also has the highest percentage of emergency contraception use. However, this sensitivity analysis fails to delineate a certain sector of Stable Users who are using highly effective methods and are already mothers because of the absence of the parity and marital status variables. The sensitivity analysis findings narrow the extent to which we can describe contraceptive behavior patterns, as women who are young and single but using effective contraception (hormonal methods from the original model results) might have very different clinical needs than women who have several children and are married and using long-term or permanent methods. As suspected, our findings elucidate more nuance and context of US contraceptive behavior typologies by including reproductive life stage variables.

Removed Women Who had a Pregnancy in the 2015-2017 Calendar

Although pregnancy is a unique and specific reproductive state for a woman to experience, the 2015-2017 NSFG calendar does not allow public use of pregnancy dates for survey participants. The data do contain yearly data for each reported pregnancy. Because of this, we cannot distinguish months of pregnancy from months of non-use while not pregnant and these states are qualitatively different. We assume that the pregnant women will be part of the high chance of pregnancy group. In order to estimate the size of that group in the high probability of pregnancy category, women who reported a pregnancy ending in any study year (n=1210) were excluded from the original sample to yield a final sensitivity analysis sample of n=4329. The LTA modeling process was repeated without these women in order to capture the contraceptive behavior typologies of women who were not pregnant during the study time period.

Research has shown that abortions are also extremely underreported in this and other national surveys.[58] Therefore, we will still be including some women who had abortions in this sensitivity analysis sample and are not able to drop all women who were pregnant from the calendar.

Appendix 14 summarizes the results of the latent class analyses at each study year 1, 2, and 3. The fit indices show that a seven-solution model was favored in years 1 and 2, while an eight-solution model was favored in year 3.

In the LCA for study year 1, seven classes were identified (Appendix 15). The first two classes are defined by their low mean months of sexual activity. However, members of Class 1, this group were split between no method and using effective methods of contraception. Further, 91% of these women had children, and 50% of them were single with a marriage dissolution. For Class 2, these women mostly used no method of contraception and had no children and were

single, never married. Class 3 is defined by the high mean months of inconsistent contraception use. Class 4 looks very similar to the Intermittent User class of the initial study. Class 5 and Class 7 look very similar in terms of mean months of sexual activity, inconsistent contraception use and condom use. Members of these are both relatively stable users of contraception but Class 5 is comprised of single women with no children, using mostly moderately effective methods of contraception while Class 7 includes married women with children, who are mostly using the most effective methods of contraception. Class 6 is similar to the Condom users from previous analyses.

The LTA model would not replicate the best log-likelihood value, even with maximum starts.

This sensitivity analysis without women who reported a pregnancy found interesting and informative results compared to the original model that included all women in the data set. In year 1, again, a seven-solution model fit the data the best, similar to the full model. Similar to the original model, two abstinent classes are identified: Single Mothers and Single Abstinent women. There still exists a small group of women (12% in the original model and 8% in the sensitivity analysis) who have a high chance of pregnancy in the sensitivity analysis, although we know that these women did not become pregnant within the three-year study period. The same “Intermittent Users” and “Condom Users” classes are identified in this sensitivity analysis as in the original model. Interestingly, this model was able to determine a distinction between “Stable Users” group from the original model. Class 5 and 7 in the sensitivity analysis are both consistently using contraception, but Class 5 described single women with no children who rely on moderately effective (or hormonal) methods of contraception while Class 7 are stable users are married women with children who use on the most effective contraceptive methods.

Interestingly, *Unstable Users* from the original model do not appear in this sensitivity analysis. Although they are a small portion of this sample, they are likely having pregnancies and are disproportionately dropped from this sensitivity analysis.

The sensitivity analysis model also illuminates specific patterns of effective and consistent contraceptive use for different subgroups. However, excluding pregnant women from the sample limits the extent to which we can understand contraceptive experiences for all women in the United States. For example, the sensitivity analysis may pick up on the nuances of those women who are effectively using contraception, but we're also eliminating those women who are erratic in their contraceptive behavior or who accidentally become pregnant while using some of these methods. As expected, this leads to sampling bias towards women who were abstinent or vigilant in their contraceptive behavior and does not adequately describe the ways in which all women use contraception. There is also the issue of the measurement error that inevitably exists in this data set due to the underreporting of spontaneous and induced abortions. The original model, although less definitive for those consistent users, captures a fuller picture of the complexities of women's contraceptive behaviors.

Discussion

Few studies have explored the changes in individual contraceptive behavior over time. Our results found seven distinct typologies of contraceptive and reproductive behavior over three-years in a nationally representative sample of US women. These typologies were not very different from the latent class model results we found in Chapter 2 from the first year of 2015-2017 NSFG calendar data. However, this formative analysis extends previous research on contraceptive typologies by examining how US women's contraceptive and reproductive behavior changes from one typical calendar year to the next.

Prevalence and Transition Rates

Our study found that around half of US women are reliably and efficiently using contraception. The highest prevalent statuses, *Consistently Covered Mothers, Single Abstinent women*, and *Stable Users* were all using effective contraception or not having sex at all. These statuses comprised over 50% of the entire study sample in any given year. They were also relatively stable. More than 90% of *Consistently Covered Mothers* remained in that status throughout the three-year study frame, making that status the most constant. These women used long-term or surgical sterilization methods of contraception and had at least one child, with a large portion of women in the status (47%) having three or more children. Some of these women might consider themselves at the end of their reproductive life course, while others might be using effective, long-term methods for child-spacing. For *Single Abstinent* women, the status prevalence declined from the first year to the third (from 29% to 26% to 23% of the sample), suggesting that as time went on, more women transitioned out of that class. This makes sense for the oversampled young women (ages 15-19) in the 2015-2017 NSFG who, as they get older, transition into having sexual relationships. For other, older *Single Abstinent* women, this might be a short-term period of abstinence. About 13% of *Single Abstinent* women switched to *Intermittent Users* every year, implying that, at the start of their reproductive life course, women are more likely to intermittently use contraception or use methods that are easily reversible as they transition in and out of sexual relationships. For *Stable Users*, around 76% remained in that status from year to year. These are women who are effectively using contraception year to year when they have sex, but tend to have fewer children than *Consistently Covered Mothers* and use moderately effective, or short-term hormonal, methods. Interestingly, over the three-year period, 13% of *Stable Users* transition into *High Chance of Pregnancy* status, possibly describing some stable contraceptive users who deliberately start having unprotected sex in order to get pregnant.

High Chance of Pregnancy women also made up about 15% percent of the sample and increased with time. This status includes women who are already pregnant and trying to become pregnant, as well as women who are ambivalent about pregnancy or contraceptive use or do not believe they can become pregnant. It also includes women who do not want to become pregnant. About 73% of women remained in the status over the three calendar years, which may reflect the time it takes to get pregnant, pregnancies running over multiple calendar years, and then the postpartum period until the eventual return to fertility. This class may also include women who are unable to get pregnant, including older women. Around 11% of the *High Chance of Pregnancy* group switched to *Stable Users* every year. These women might be postpartum and using effective contraception to prevent a short interpregnancy interval. *Condom Users* were also a consistent group over the three-year study period, making up 11 to 13% of the sample in each year. Around 12% of *Condom Users* transition to *Unstable Users* in any given study year. The *Unstable Users* are the smallest status in this sample. They are a small group year to year (3-5%), and transition in and out of other statuses frequently, but this is also what defines them as a group of contraceptive users. They might be women who cannot find a method that works for them, as over 85% of these women switch methods in a year. They are having sex frequently and having unprotected sex about half of the time. A large portion of this latent status, 27.5%, move into *High Chance of Pregnancy* status, suggesting that *Unstable Users* might become pregnant after a period of unstable contraception use. Another 15.6% of these women transition to *Condom Users* while a small portion, 12.0%, become *Stable Users*. This is a small group of women who might be the most receptive to a tailored, clinical intervention to help them address their dynamic contraceptive needs. Although all women should be empowered to choose a method of birth control that she can use correctly and consistently over time, when a woman

presents signs of being an *Unstable User*, that may indicate that a woman is at high risk of unintended pregnancy or unsatisfied with her family planning options. Clinicians may initiate more in-depth, contraceptive counseling that includes developing a more personal and trusting relationship with clients, optimizing decision making, communication of side-effects and risks, and personalized discussion on future fertility preferences.[82]

Finally, *Intermittent Users* comprised around 10% of our sample but only 46.1% remained in this class in any given year. These women, unlike the other women in the sample who have sex most months or not at all, are infrequently having sex throughout the year. They have 0.5 monthly average of having inconsistent contraceptive use, which puts them at an elevated risk of pregnancy. However, 15.7% of these women become *Single Abstinent* women in each year. One theory is that these women have a romantic or sexual partner for a short time, then, when that relationship is over, they return to abstinence. Also, 12.6% of *Intermittent Users* become *Condom Users* suggesting that some *Intermittent Users* go on to have increased sexual activity and are consistently using condoms with these partners.

By design, measures of life stage, parity and marital status were an integral part of the formation of contraceptive states and the results show that there was relatively high degree of separation by life stage variables. Single women with no children tended to be *Single Abstinent*, *Intermittent Users*, or *Stable Users* while most married women with children used a permanent or long-acting method as *Consistently Covered Mothers*. *Condom Users* and *Intermittent Users* were using short-term, reversible methods. This is consistent with other reproductive life stage research. In a large national survey from Australia, women at low parity were more likely to use oral contraception, while women with two or more children are more likely to use longer term or

permanent methods.[77] These findings demonstrate that life course factors play an important role in understanding contraceptive preferences and behavior dynamics.

Changes in Contraceptive Behavior after a Pregnancy

Controlling for age, education, race and ethnicity, federal poverty level, and religion, this study showed how women change contraceptive and reproductive trajectories when they experience, and report, both unintended and intended pregnancies. Because of the small sample sizes of women who had unintended pregnancies in study years 1 and 2, these results are suggestive of women's pregnancy experiences, but not definitive. It should also be noted that these results do not allow us to disentangle directionality of what state an unintended pregnancy originated from because the NSFG public use data file only contains the year in which a pregnancy ended. The women who did report an intended pregnancy in a given year had a higher probability of transition to *High Chance of Pregnancy Status* suggesting that more of these women may be carrying these pregnancies to term, having babies and becoming postpartum. Fewer women with unintended pregnancies transition to this state. Some of these women who experience an unintended pregnancy may obtain abortions, and begin using contraception such as those women who transition to *Stable Users, Consistent Covered Mothers* or *Condom Users*. For those women who were *Unstable Users* in Year 1, 35% who had unintended pregnancies and 31% who had intended pregnancies transitioned to *Condom Users*. The results are similar in Year 2, although in Year 2, about a quarter of the women remain in *Unstable Users* status in both groups of women.

Pregnancy experiences affect every individual differentially. Some women who have an unintended pregnancy may be compelled to significantly change their contraceptive behavior while others are not. Our study findings show that for some women who were not already consistently using contraceptives, having an unintended pregnancy may press them into stable

contraceptive use, although that is primarily condom use behavior. In a qualitative study of pregnant women, Kendall et al. saw that many women used condoms who disliked the side-effects of hormonal methods, or found accessing these methods to be burdensome or financially unfeasible.[83] For women who were already consistently using contraception and experienced an unintended pregnancy, the majority remained stable users of contraception. In fact, among stable users who had unintended pregnancies, 25% and 16% of them switched to the most effective method of contraception in years 2 and 3, respectively, by transitioning to *Consistently Covered Mothers*. These findings show a complex story behind the multi-faceted decision-making process surrounding sex, contraception and childbearing.

Limitations

There are a few limitations to this current study of contraceptive behavior dynamics. The current study uses eight items to capture contraceptive behavior, exposure, and life stage development as well as pregnancy intention items. To measure contraceptive behavior and intendedness of pregnancies, the NSFG asks women to retrospectively recall their behavior (on a month-by-month basis over a period of three to four years) and whether they wanted to have a baby right before they conceived each of the pregnancies she experienced. These retrospective measures have the potential for recall bias, especially for pregnancy intention as women's perceptions of a past conception can change over time.[84] There have been a growing number of innovations in the Life History Calendar applications in the NSFG.[85] The Life History calendar provides a matrix of visual cues which respondents can use to help them recall the timing of life events. This data collection tool increases the ability of the life history calendar in the NSFG to document the timing and sequences of contraceptive behavior and sexual activity in the US population. Additionally, the 2015-2017 NSFG data set reports only the year in which each pregnancy ended for all respondents' reported pregnancies. Therefore, we do not have the details

of pregnancy timing. We can only report the year in which a woman's pregnancy ended and cannot describe what specifically was happening with individual women before they became pregnant. With a more specific timeframe, future studies may be able to differentiate among *High Chance of Pregnancy* women (i.e., those who were erratic in their contraceptive behavior leading them to pregnancy) and those who were deliberate in moving into a higher probability of pregnancy.

An important limitation within this analysis involves the underreporting of induced and spontaneous abortions within the data set. Although the NSFG is the most comprehensive source of information on pregnancy and contraceptive use among reproductive-aged women in the United States, abortion underreporting is a major issue.[58] Abortion underreporting will introduce measurement error in some of the derived variables for the analysis including use and types of contraceptive methods during each month. This type of measurement error should have a small effect on the latent transition analysis because the percentage of months of data that would be affected by abortion mis-reporting will be small relative to the total number of months of use in the sample. In addition, abortion and other underreported unintended pregnancies will potentially bias our results on how women transition in their contraceptive status when they have an unintended pregnancy. Again, our results are suggestive and not definitive. Transition patterns of other women who have unintended pregnancies, but omit these from their history, limit the extent to which we can describe unintended pregnancy experiences. Therefore, these results should be interpreted with some caution.

Another limitation within this study analysis is the time-invariant variables "Federal Poverty Level" and "Education." These responses were gathered at the interview date and are not part of the calendar data, and therefore do not reflect the prior three years of the respondents'

life. However, published US economic literature shows that on average, poverty level does not fluctuate often between the categories of this variable, especially over a short and recent three-year period [59,60].

There are limitations with the constructed indicators and the latent transition model. First, latent class analysis models were used to capture the underlying latent construct of contraceptive behavior each year, over the course of the three years of calendar data. We chose to model contraceptive behavior in calendar years because it is a natural unit of time, there is a seasonality of childbirth, and most health insurance plans cover an annual well-woman exam.[86,87] However, that unit of time is ultimately arbitrary and another time-frame could have been modeled. Second, the LTA models stage-sequential development in our eight indicator variables. In doing so, we inevitably simplify and collapse the ways in which all women of reproductive age in the United States have sex, use contraception, get married, and have children. In future studies, other important indicators should be included in analysis, such as contraception and pregnancy intentions over time. This study used five predictor variables but more could be used to provide a richer depiction of women's contraceptive behavior than this study explored. Future studies could also explore distal outcomes such as sexually transmitted infections or negative birth outcomes that might illuminate the conditions under which certain patterns are tied to other reproductive health outcomes.

Implications

Contraceptive use is nearly universal in the United States, yet very little is known about individual's dynamic contraceptive use over time. This paper uses an advanced statistical technique – latent transition analysis – to address this gap in the family planning literature. The results find seven contraceptive behavior states that describe the multidimensional context of relationships, sex and contraceptive use behavior over time, from a woman-centered perspective.

Identifying the existence, relative size, and trajectories of interpretable subgroups helps to develop new hypotheses about women's contraception behavior and experiences. For example, a relatively small proportion of women belong to the high-risk profile of unstable contraceptive users in any year, but a large portion of these women remain at risk of pregnancy while others are able to transition to using condoms or other methods of contraception consistently. Pregnancy experiences also have distinctive effects for groups of women. For some women, an unintended pregnancy experience may trigger a change their contraceptive behavior. For others, it does not. As other studies have reported, there is a small group of women who have unintended pregnancies at any point in time, but our study confirms that this group is dynamic [2]. At any given time, there is a small number of women who move into and out of an unstable contraceptive state. Overall, these trajectories suggest that contraceptive and reproductive health experiences, including intentional and unintentional pregnancies, are heterogeneous in the United States. Our findings underscore the importance of capturing the complexities of women's fertility-controlling experiences, and enhanced longitudinal integration of contraceptive behaviors within family planning research and clinical practice.

Tables

Table 6. Distribution of Respondents by Constructed Latent Transition Variables and Age for each Study Year, NSFG 2015-2017; n=5539

	Year 1		Year 2		Year 3	
	N	%	N	%	N	%
Most Frequent Type of Method Used						
Most Effective	1218	22.0%	1352	24.4%	1457	26.3%
Moderately Effective	997	18.0%	995	18.0%	960	17.3%
Least Effective	822	14.8%	854	15.4%	884	16.0%
No Method	2502	45.2%	2353	42.2%	2238	40.4%
Condom Use Frequency (Months)						
0	4331	78.2%	4292	77.5%	4189	75.6%
1	157	2.8%	198	3.6%	231	4.2%
2	141	2.6%	102	1.8%	126	2.3%
3	93	1.7%	106	1.9%	100	1.8%
4	80	1.4%	89	1.6%	105	1.9%
5	58	1.1%	70	1.3%	86	1.6%
6	59	1.1%	53	1.0%	65	1.2%
7	46	0.8%	56	1.0%	56	1.0%
8	41	0.7%	58	1.1%	68	1.2%
9	44	0.8%	49	0.9%	43	0.8%
10	44	0.8%	36	0.7%	47	0.9%
11	26	0.5%	39	0.7%	42	0.8%
12	419	7.6%	391	7.1%	381	6.9%
Emergency Contraception Use (Months)						
0	5480	98.9%	5453	98.5%	5412	97.7%
1+	59	1.04%	86	1.58%	127	2.28%
Sexual Activity (Months)						
0	1642	29.6%	1425	25.7%	1287	23.2%
1	137	2.5%	154	2.8%	150	2.7%
2	123	2.2%	121	2.2%	131	2.4%
3	105	1.9%	117	2.1%	114	2.1%
4	125	2.3%	118	2.1%	138	2.5%
5	96	1.7%	143	2.6%	119	2.2%
6	113	2.0%	122	2.2%	147	2.7%
7	123	2.2%	142	2.6%	135	2.4%
8	118	2.1%	134	2.4%	159	2.9%
9	119	2.2%	159	2.9%	155	2.8%
10	149	2.7%	163	2.9%	175	3.2%
11	104	1.9%	148	2.7%	171	3.1%
12	2585	46.7%	2593	46.8%	2658	48.0%

Inconsistent Contraception Use (Months)						
0	4484	81.0%	4473	80.8%	4028	72.7%
1	98	1.8%	113	2.0%	127	2.3%
2	75	1.4%	65	1.2%	152	2.7%
3	61	1.1%	76	1.4%	117	2.1%
4	59	1.1%	62	1.1%	105	1.9%
5	57	1.0%	49	0.9%	111	2.0%
6	56	1.0%	65	1.2%	83	1.5%
7	49	0.9%	53	1.0%	88	1.6%
8	48	0.9%	44	0.8%	64	1.2%
9	63	1.1%	57	1.0%	90	1.6%
10	50	0.9%	52	0.9%	75	1.4%
11	50	0.9%	30	0.5%	79	1.4%
12	389	7.0%	400	7.2%	420	7.6%
Frequency of Method Type Switches						
0	4338	78.3%	4225	76.3%	4133	74.6%
1	711	12.8%	762	13.8%	754	13.6%
2+	490	8.9%	552	9.9%	652	11.9%
Marital Status						
Married throughout Study Period	1560	28.2%	1629	29.4%	1679	30.3%
Single, Never Married	3230	58.3%	3122	56.4%	3024	54.6%
Single, Previously Married (Prior to the Study Period)	535	9.7%	578	10.4%	621	11.2%
Married Within Study Year	136	2.5%	134	2.4%	130	2.4%
Marriage Dissolution Within Study Year	78	1.4%	76	1.4%	85	1.5%
Parity						
0 Live Births	2738	49.4%	2618	47.3%	2517	45.4%
1 Live Birth	1069	19.3%	1067	19.3%	1036	18.7%
2 Live Births	954	17.2%	1026	18.5%	1085	19.6%
3+ Live Births	778	14.1%	828	14.9%	901	16.3%

Age (Mean, Range)	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
	29.0	13	47	30.0	14	48	31.0	15	49
Total	5539	100%		5539	100%		5539	100%	

Table 7. Social and Demographic Characteristics of the Sample, NSFG 2015-2017, n=5539

	N (n=5539)	%		
Education				
Less than High School	1309	23.6%		
High School Graduate	1251	22.6%		
Some College	1462	26.4%		
College Degree	743	13.4%		
Graduate School or Professional Degree	774	14.0%		
Race and Ethnicity				
White Non-Hispanic	2667	48.2%		
Black Non-Hispanic	1333	24.1%		
Hispanic	1070	19.3%		
Other	469	8.5%		
Religion				
No Religion	1258	22.7%		
Catholic	1104	19.9%		
Protestant	2716	49.0%		
Other Religions	461	8.3%		
Pregnancies[4]				
Year 1				
No Pregnancies	5060	91.4%		
Intended Pregnancies	277	5.0%		
Unintended Pregnancies	202	3.6%		
Year 2				
No Pregnancies	5047	91.1%		
Intended Pregnancies	300	5.4%		
Unintended Pregnancies	192	3.5%		
Federal Poverty Level	Mean	Min	Max	
	230.1%	5.0%	500.0%	
Total	5539	100%		

[4] Two women in Year 1, and two women in Year 2 had two unintended pregnancies within each study year

Figure 1. Conceptual Model of Latent Transition Analysis and Covariates

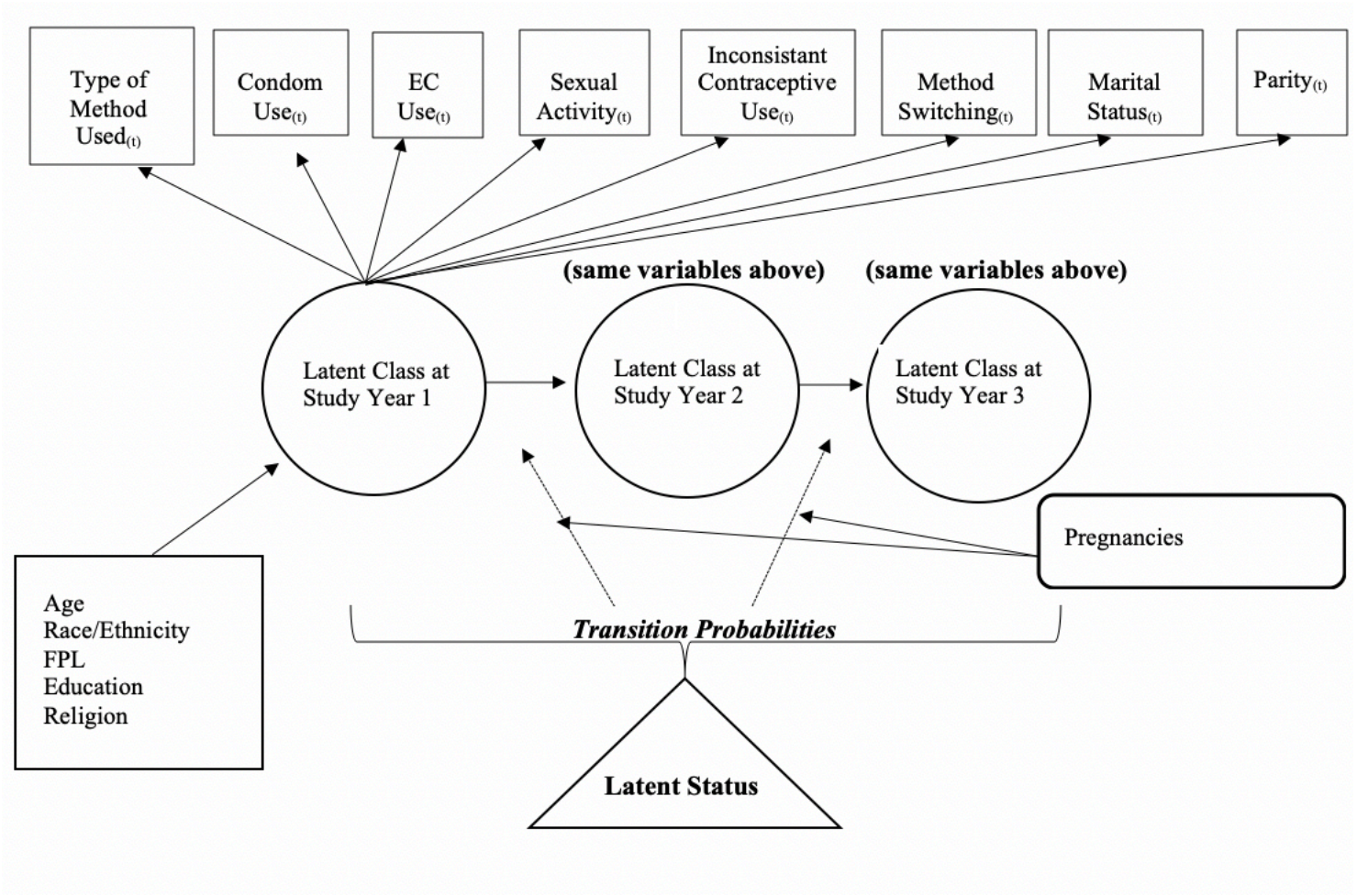

Table 8. Results of LCA at Each Time Point; NSFG 2015-2017; n=5539

	Number of Parameters Estimated	Log-likelihood	AIC	BIC	ABIC	Entropy	LMR-LTR (*p*)	% in Smallest Class
Time 1								
2-solution	33	-63380.496	126826.992	127045.438	126940.574	0.983	-	33.5%
3-solution	50	-52404.185	104908.370	105239.349	105080.464	0.984	21464.3 (<0.001)	16.6%
4-solution	67	-44706.804	89547.608	89991.119	89778.214	0.984	17682.8 (<0.001)	16.2%
5-solution	84	-43010.246	86188.492	86744.536	86477.610	0.977	3370.1 (<0.001)	9.7%
6-solution	101	-42227.670	84657.340	85325.917	85004.970	0.974	1554.5 (<0.001)	5.1%
7-solution	118	**-41693.857**	**83623.714**	**84404.823**	**84029.855**	0.965	1060.4 (<0.001)	5.1%
8-solution	Best log-likelihood not replicated							
Time 2								
2-solution	33	-65232.131	130530.261	130748.707	130643.843	0.981	-	30.7%
3-solution	50	-54101.136	108302.272	108633.250	108474.366	0.982	22101.7 (<0.001)	16.3%
4-solution	67	-46044.946	92223.892	92667.403	92454.497	0.984	19230.5 (<0.001)	16.1%
5-solution	84	-44390.783	88949.566	89505.609	89238.683	0.977	3285.9 (<0.001)	10.2%
6-solution	101	-43630.398	87462.795	88131.372	87810.425	0.971	1510.5 (<0.001)	5.7%
7-solution	118	**-43155.767**	**86547.535**	**87328.644**	**86953.676**	0.965	1516.9 (<0.001)	5.4%
8-solution	Best log-likelihood not replicated							
Time 3								
2-solution	33	-67969.353	136004.705	136223.151	136118.287	0.980	-	28.0%
3-solution	50	-58215.312	116530.625	116861.603	116702.719	0.975	19375.9 (<0.001)	28.0%
4-solution	67	-51296.522	102727.044	103170.555	102957.650	0.979	13307.0 (<0.001)	18.7%
5-solution	84	-49616.557	99401.113	99957.157	99690.231	0.964	1921.5 (<0.001)	11.3%
6-solution	101	-48090.027	96382.054	97050.631	96729.684	0.972	545.5 (<0.001)	5.1%
7-solution	118	**-47620.331**	**95476.662**	**96257.772**	**95882.804**	0.937	933.024 (<0.001)	5.1%
8-solution	Best log-likelihood not replicated							

Table 9. Probabilities of Item Parameters on Contraceptive Behavior Dynamics and Exposure Variables; NSFG 2015-2017; n=5539

Latent Status	*LS1*	*LS2*	*LS3*	*LS4*	*LS5*	*LS6*	*LS7*
Probability							
Most Frequent Method							
Most Effective Method	0.10	0.21	0.82	0.11	0.05	0.09	0.05
Moderately Effective Method	0.09	0.51	0.09	0.08	0.19	0.22	0.08
Least Effective Method	0.0	0.16	0.07	0.05	0.76	0.01	0.48
No Method	0.81	0.12	0.02	0.76	0.0	0.68	0.39
Emergency Contraception Use							
No	1.0	0.98	1.0	1.0	0.96	0.95	0.93
Yes	0.0	0.02	0.0	0.0	0.04	0.05	0.07
Switching							
0	0.95	0.80	0.95	0.71	0.64	0.31	0.14
1	0.04	0.14	0.04	0.22	0.19	0.25	0.42
2+	0.01	0.06	0.01	0.07	0.17	0.44	0.43
Parity							
0	0.80	0.56	0.00	0.29	0.50	0.63	0.40
1	0.08	0.34	0.10	0.32	0.19	0.19	0.28
2	0.06	0.10	0.43	0.23	0.19	0.12	0.22
3+	0.06	0.00	0.47	0.16	0.12	0.07	0.11
Marital Status							
Single, Never Married	0.85	0.61	0.15	0.36	0.62	0.75	0.58
Married	0.03	0.27	0.64	0.50	0.27	0.08	0.30
Single, Previously Married	0.11	0.06	0.17	0.09	0.08	0.12	0.08
Married within Study Period	0.0	0.05	0.02	0.04	0.02	0.03	0.03
Dissolution within Study Period	0.01	0.01	0.02	0.01	0.01	0.02	0.01
Mean (in Months Per Year)							
Condom Use	0.0	0.1	0.0	0.0	10.0	1.6	5.4
Inconsistent Use	0.0	0.0	0.0	9.2	0.0	0.5	5.7
Sexual Activity	0.0	10.8	11.2	10.9	10.8	3.2	10.2

Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

Table 10. Latent Status Prevalence (δ Estimate) and Transition Matrix (τ Estimates) Over Three Time Points on Women's Contraceptive and Exposure Variables; NSFG 2015-2017; n=5539

				δ Estimate			
Time	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
Year 1	0.29	0.15	0.18	0.14	0.13	0.08	0.03
Year 2	0.26	0.15	0.18	0.15	0.11	0.10	0.05
Year 3	0.23	0.16	0.18	0.17	0.11	0.10	0.05
				τ Estimate			
LS1	0.790	0.023	0.009	0.008	0.026	**0.129**	0.015
LS2	0.025	0.759	0.000	**0.130**	0.036	0.035	0.016
LS3	0.015	0.000	0.912	0.051	0.013	0.005	0.004
LS4	0.020	**0.109**	0.058	0.733	0.020	0.019	0.042
LS5	0.023	0.087	0.019	0.035	0.643	0.072	**0.121**
LS6	**0.157**	0.077	0.011	0.082	**0.126**	0.461	0.086
LS7	0.000	**0.120**	0.050	**0.275**	**0.156**	0.077	0.323

LS stands for latent status; Bold indicates the probability of transitioning to a different status from >0.10.
Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

Table 11. Predicted Probabilities of Covariates (Standard Error) on the Latent Status at Study Year 1; NSFG 2015-2017; n=5539

	Time 1 Latent Status (β Parameters)						
	LS1	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
Age at Mean Age in Study Year 1 (29.03)	0.29 (0.01)	0.17 (0.01)	0.13 (0.01)	0.16 (0.01)	0.14 (0.01)	0.09 (0.00)	0.03 (0.00)
Federal Poverty Level at Mean (230%)	0.30 (0.01)	0.14 (0.01)	0.18 (0.00)	0.14 (0.00)	0.13 (0.00)	0.08 (0.00)	0.02 (0.00)
Race							
White	0.31 (0.01)	0.16 (0.01)	0.19 (0.01)	0.14 (0.01)	0.12 (0.01)	0.06 (0.00)	0.02 (0.00)
Black	0.29 (0.01)	0.16 (0.02)	0.13 (0.01)	0.14 (0.01)	0.15 (0.01)	0.11 (0.01)	0.03 (0.01)
Hispanic	0.27 (0.01)	0.12 (0.02)	0.21 (0.01)	0.14 (0.01)	0.13 (0.01)	0.10 (0.01)	0.02 (0.01)
Other	0.34 (0.02)	0.12 (0.02)	0.16 (0.02)	0.16 (0.02)	0.12 (0.02)	0.07 (0.1)	0.02 (0.01)
Education							
<High School	0.43 (0.01)	0.08(0.01)	0.22 (0.01)	0.13 (0.01)	0.08 (0.01)	0.04 (0.01)	0.02 (0.00)
High School Grad	0.28 (0.01)	0.15 (0.01)	0.20 (0.01)	0.15 (0.01)	0.11 (0.01)	0.08 (0.01)	0.02 (0.00)
Some College	0.23 (0.01)	0.17 (0.01)	0.18 (0.01)	0.14 (0.01)	0.16 (0.01)	0.10 (0.01)	0.02 (0.00)
College or Greater	0.24 (0.01)	0.18 (0.01)	0.14 (0.01)	0.14 (0.01)	0.16 (0.01)	0.12 (0.01)	0.03 (0.01)
Religion							
No Religion	0.28 (0.01)	0.18 (0.01)	0.14 (0.01)	0.13 (0.01)	0.15 (0.01)	0.09 (0.01)	0.02 (0.00)
Catholic	0.29 (0.01)	0.16 (0.01)	0.18 (0.01)	0.15 (0.01)	0.13 (0.01)	0.08 (0.01)	0.02 (0.00)
Protestant	0.30 (0.01)	0.13 (0.01)	0.19 (0.01)	0.15 (0.01)	0.12 (0.01)	0.09 (0.01)	0.02 (0.00)
Other	0.36 (0.02)	0.11 (0.01)	0.20 (0.02)	0.10 (0.01)	0.13 (0.02)	0.06 (0.01)	0.04 (0.01)

Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

Table 12. Estimated Transition Probabilities Presented by Women Who Reported Unintended Pregnancies; NSFG 2015-2017

Women who had an *Unintended* Pregnancy in Study Year 1 (n=202)							
			Study Year 2				
Study Year 1	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	0.42	0.32	0.18	0.04	0.01	0.03	0.00
LS2	0.21	0.36	0.25	0.09	0.03	0.06	0.00
LS3	0.08	0.32	0.28	0.15	0.06	0.10	0.01
LS4	0.02	0.23	0.28	0.20	0.12	0.13	0.02
LS5	0.01	0.15	0.25	0.23	0.19	0.14	0.03
LS6	0.00	0.09	0.21	0.25	0.27	0.13	0.05
LS7	0.00	0.05	0.16	0.24	0.35	0.12	0.08

Women who had an *Unintended* Pregnancy in Study Year 2 (n=192)							
			Study Year 3				
Study Year 2	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	0.36	0.26	0.15	0.18	0.01	0.02	0.02
LS2	0.16	0.27	0.16	0.30	0.03	0.04	0.04
LS3	0.06	0.22	0.15	0.40	0.05	0.05	0.07
LS4	0.02	0.16	0.12	0.44	0.09	0.06	0.11
LS5	0.00	0.10	0.09	0.45	0.13	0.06	0.17
LS6	0.00	0.06	0.06	0.42	0.18	0.06	0.22
LS7	0.00	0.03	0.04	0.37	0.24	0.05	0.27

Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

Table 13. Estimated Transition Probabilities Presented by Women Who Reported Intended Pregnancies; NSFG 2015-2017

Women who had an *Intended* Pregnancy in Study Year 1 (n=277)								**Women who had an *Intended* Pregnancy in Study Year 2 (n=300)**							
	Study Year 2								***Study Year 3***						
Study Year 1	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***	***Study Year 2***	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	0.32	0.28	0.25	0.11	0.01	0.03	0.00	***LS1***	0.34	0.29	0.06	0.25	0.01	0.03	0.02
LS2	0.14	0.28	0.31	0.19	0.04	0.04	0.00	***LS2***	0.14	0.28	0.07	0.39	0.02	0.06	0.04
LS3	0.05	0.22	0.32	0.28	0.07	0.06	0.00	***LS3***	0.05	0.23	0.06	0.48	0.04	0.07	0.07
LS4	0.01	0.15	0.29	0.34	0.12	0.07	0.02	***LS4***	0.01	0.16	0.05	0.52	0.07	0.08	0.11
LS5	0.00	0.09	0.25	0.38	0.18	0.07	0.03	***LS5***	0.00	0.10	0.04	0.52	0.11	0.08	0.15
LS6	0.00	0.05	0.20	0.39	0.24	0.07	0.05	***LS6***	0.00	0.06	0.02	0.49	0.15	0.08	0.20
LS7	0.00	0.03	0.15	0.38	0.31	0.06	0.07	***LS7***	0.00	0.03	0.02	0.43	0.20	0.07	0.25

Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

CHAPTER 4: CONCLUSIONS AND IMPLICATIONS

Overview of Findings

This dissertation research applied multiple factors of women's contraceptive behavior to build latent contraceptive behavior typologies, and explored how these typologies can change over time among a national sample of reproductive-aged women. In Chapter 2, we examined women's contraceptive behavior typologies over a typical calendar year in a national sample of US women aged 13 to 48. Seven classes were identified based on contraceptive behaviors, exposures, and life stage variables, including a single mothers class, an intermittent users class, single abstinent women, stable users, women who frequently switch methods, women who mostly prefer using condoms, and women who have the greatest probability of pregnancy. Some of these classes were associated with sociodemographic variables including age group, race and ethnicity, education, and federal poverty level. This analysis is the first such application of person-centered methodology, latent class analysis, to nationally representative contraceptive calendar data in the United States. Identifying typologies of contraceptive behavior can inform clinical practice by tailoring population-level family planning interventions to individual-level contraceptive needs, expectations, and preferences.

In Chapter 3, we examined individual patterns of contraceptive use over a three-year period in order to understand how the contraceptive typologies identified in Chapter 2 evolve over time. When analyzing three years of contraceptive behavior typologies, seven statuses, very similar to the one-year classes from Chapter 2, emerged. They included consistently covered mothers, single abstinent women, stable users, high chance of pregnancy women, intermittent

users, condom users, and unstable users. Instead of the single mothers class from the one-year of analysis, a larger mothers class appeared in the three-year longitudinal analysis. In addition, the method switchers from the one-year analysis became more of an unstable users status, comprised of women who frequently transition in and out of other statuses, have unprotected sex, and switch contraceptive method type regularly over the three-year period. Single abstinent women, consistently covered mothers, and stable users were relatively durable statuses with over 75% of women remaining in those statuses over the three-year analysis. Although about 73% of high chance of pregnancy women remain in that class from year to year, about 11% move to Stable Users. Only 64% of condom users remained as condom users from one year to the next with about 12% moving to unstable users. Only 46% of intermittent users remained in that status from year to year, with 16% become single abstinent users and almost 13% becoming condom users. Finally, only about a third (32%) of unstable users remained in that status. Almost 30% become high risk of pregnancy women, 15.6% became condom users, and 12% transitioned to stable use from one calendar year to the next. This study was the first of its kind to use this type of longitudinal modeling and has important implications for clinicians and researchers describing the ways in which women dynamically use contraceptive methods over time.

Limitations

Limitations specific to each research aim are detailed in Chapters 2 and 3, but a few broader limitations are discussed here. First, both aims used secondary data analysis, meaning the data were not collected for the purpose of these analyses. However, the National Survey of Family Growth has been an integral part of the federal statistical system, within the National Center for Health Statistics, since 1973. The primary purpose of the survey has been to produce reliable national estimates of factors affecting pregnancy, including sexual activity, contraceptive use, and infertility, and factors affecting marriage, divorce, cohabitation, and family building

among many other related topics. The overall response rate for the 2015-2017 NSFG for ages 15-49 was 66.7% for women.[46] The availability and use of this comprehensive national data set is a great advantage. This survey contains many variables of interest to this dissertation analysis, all measured by a standardized approach that has been validated over decades of implementation.

A second major limitation is the retrospective nature of the calendar data used in this analysis that are subject to the respondents' quality of recall. Use of calendar methods for querying respondents about contraceptive experience has become standard practice in large-scale population surveys, including the NSFG used in this analysis and the widely-used Demographic and Health Surveys (DHS) in low and middle income countries. In the NSFG, the survey asks participants about their retrospective contraceptive use behavior and sexual activity over a short and recent three-year period. Retrospective reports in surveys are subject to recall bias, which can affect the quality and usefulness of the resulting data. One research study in Bangladesh examined overlapping contraceptive calendars to estimate the consistency of responses. They found that more than one-third of women were discordant in their reports in one reference month and 25% reported different methods at two reports of the same time points.[88] Women using condoms or traditional methods and those with more complex reproductive histories were least likely to report reliability. However many studies, including the one previously described, assess the quality of contraceptive-use data collected using calendar data from low and middle income countries.[89] Accuracy in reporting autobiographical events is dependent on several factors and has been shown to be positively associated with education level.[90] Contraceptive calendar reliability may look very different in a US context where there are higher levels of female literacy. Additionally, there have been a growing number of innovations in the Life History Calendar applications in the NSFG.[85] The Life History calendar provides a matrix of visual cues

which respondents can use to help them recall the timing of life events. This data collection tool increases the ability of the life history calendar in the NSFG to document the timing and sequences of contraceptive behavior and sexual activity in the US population. Lastly, in this dissertation analysis, latent class analysis was used, a measurement model, to capture the categorical latent variable at each time period. This type of measurement model will account for some of the inevitable measurement error in the independent contraceptive behavior variables from the calendar data, as multiple indicators identify the latent contraceptive behavior profile.[91]

Knowledge Contribution

This dissertation research contributes to the understanding of women's lived contraceptive experiences. This analysis applied innovative statistical methods with longitudinal data to provide a new window to the dynamic nature of women's contraceptive experience that cannot be gained by examining episodic or cross-sectional measures alone. The contraceptive calendar is an underutilized source of data which can be used to examine recent periods of US women's contraceptive experiences. Latent class analysis, and a special version of LCA for longitudinal data, latent transition analysis, are statistical methods that have the unique ability to use an array of observed variables to organize a population into meaningful subgroups. This is believed to be the first such application of LCA and LTA methods to nationally representative longitudinal contraceptive data in the US.

One goal of this dissertation was to develop new ways to characterize the nuance of women's contraceptive experiences and to describe how these experiences manifest in various stages of life. Using LCA/LTA to identify multifaceted contraceptive behavior groups, this dissertation was able to characterize women's contraceptive and pregnancy experiences over three years, allowing multiple transitions across a three-year period. In doing so, the results of this analysis provide new context for women's contraceptive behavior statuses in which

pregnancies might occur. The findings also corroborate previous findings on contraceptive behavior. For example, our results identify a small group of women in the US who exhibit a certain high-risk profile of contraceptive behavior. Other studies have found a similarly small group of women who are most at risk of an unintended pregnancy. In fact, the vast majority of unintended pregnancies occur among those women in this risk profile i.e. women who use no method or have gaps in contraceptive use.[2] Our study also demonstrate that life course factors play an important role in understanding contraceptive behavior dynamics, similar to other research on reproductive life course. Single women with no children were more likely to be use short-term reversible methods while married women with children were more likely to use long-acting methods. Gray and McDonald found similar results in their study of contraceptive use among Australian women.[77]

One important strength of this study is the shift away from macro-level average of contraceptive behaviors to describing dynamic patterns of contraceptive use at the individual level. For example, our results describe how single, abstinent women transition into sexual activity patterns. Most of these women start having sex intermittently, relying on condoms and hormonal methods of contraception. The prevalence of the distinct contraceptive behavior typologies provide new insights into how common certain groups of contraceptive users are and how stable. Some of our results confirm what we might already hypothesize about contraceptive behaviors (e.g. many women are stable and consistent users of contraception). The high prevalence of stable contraceptive users indicates that many of the classes represent these relatively stable behaviors with low switching at least between broad method groups, and there is a lot of stability from year to year. A fairly small group of women that exhibit the most unstable patterns of use, i.e. episodes of method switching, erratic unprotected sexual activity, both within

a year and across years. Using latent class and latent transition analysis, we were able to summarize contraceptive behavior typologies in order to provide a deeper understanding of how contraceptive dynamics manifest at the individual level, how common these behaviors are, and how stable they are over time.

Future Research Studies

This dissertation included an application of LCA and LTA models with eight contraceptive behavior, sexual activity, and life stage variables. These methods and variables were used to describe patterns of reproductive health behavior using three years of contraceptive calendar data in a national sample of US women. However, the results of this analysis call for future studies to explore modeling extensions, different measurements of contraceptive behavior, and subpopulations. As specified in the Theory of Reasoned Action, behavioral intentions are important aspects of health trajectories.[92] Because of the lack of intention data in the contraceptive calendar, both contraceptive and pregnancy intentions were not accounted for in the formation of contraceptive behavior subgroups. But contraceptive and pregnancy intentions provide an indication of how well individuals achieve their reproductive goals. Pregnancy intentions at any given time in a woman's life can be ambivalent, contradictory, or unspecified.[93] However, including *prospective*, longitudinal indicators of fertility intentions in future studies will enhance our understanding of reproductive trajectories. For example, weekly journal data that captures current fertility intentions, along with sexual activity and contraceptive use, could strengthen the results of an analysis on reproductive behavior. Additionally, qualitative data that specifically explore the reasoning for intentions and behaviors at specific points in time could add depth to our broad understanding of dynamic contraceptive behavior patterns. Including prospective, longitudinal contraception intention measures can help illuminate unmet contraceptive needs, relationship dynamics, and method dissatisfaction among women the United

States. This study intentionally explored a broad view of women's contraceptive behavior trajectories across all women of reproductive age in the United States. Future studies may find illuminating results of patterns of women in different subgroups, such as postpartum women, adolescents, or women in the US without health insurance.

Finally, this dissertation analysis used mixture models to find subgroups in a data set. Future studies should take advantage of new and improved software packages that have significantly eased the implementation burden for machine learning methods. These methods use automated statistical models to find patterns in large data sets. For example, unsupervised clustering methods partition observations in a data set into distinct groups, so that the observations within each group are similar to each other.[94] Machine learning methods would be able to specify different dissimilarity measures, or linkages, between all pairs of observations. For example, we could maximize intercluster dissimilarity or the differences between contraceptive behavior typologies, or minimize intercluster dissimilarity, by finding the common patterns between the observations in one cluster of contraceptive behavior and the observations in another. Using these and other advanced statistical models may provide new opportunities to understand complex data sets, with the ability to gain new insights into the complexities of women's multidimensional contraceptive experiences.

Implications for Programs, Providers, and Public Health

By contributing to the understanding of how contraception use fits into the lives of women across the United States, this dissertation research can be used to inform evidence-based family planning research and practice. First, the findings from these analyses can strengthen clinical contraceptive counseling interventions. In the family planning community, universal LARC access and use has been championed by clinicians and academics alike due to LARC methods' robust safety, effectiveness, and user friendliness.[95] Indeed, advances in LARC devices

and uptake have had far-reaching family planning impacts at the population level. But the findings from these analyses emphasize the heterogeneity of contraceptive experiences among women in the United States. For example, women who consistently use condoms every month of the year was a prominent group of women in both a one-year analysis and over the three-year longitudinal study period. Generally, in family planning literature, a person using an effective method, such as a LARC method, is considered a positive outcome, while someone not using an effective method is considered a negative outcome. Accordingly, in this dissertation, condoms were defined as a "least effective" type of method because of their frequent incorrect or erratic use. But the women and couples who rely on male condoms are a substantial and enduring group. Very small numbers of these women transitioned to other statuses that relied on more effective methods of contraception. It is possible that some of these women might benefit from improved contraceptive access and family planning program. On the other hand, many of these women may not want to "advance" in their contraceptive method efficacy to LARC methods or even hormonal methods. These women might be satisfied with their status as condom users and ought to be framed as a family planning success.

This dissertation provides evidence on the heterogeneity of reproductive health experiences across the United States. Unintended pregnancy measures or frequency of LARC method use are outdated measures of the success of family planning programs and limits the extent to which research can capture the multidimensional processes of individual contraceptive behavior dynamics. Family planning research should take into account behavior and intention diversity and focus on measuring the degree of contraceptive autonomy.[66] By studying contraceptive autonomy, research studies the factors that need to be in place in order for a person to decide for themselves what they want in regards to contraceptive use. Are women in the

United States receiving the contraceptive care and methods they desire? Are they achieving their fertility goals?

Second, this dissertation introduces new understanding of US women's longitudinal contraceptive behavior patterns within the family planning literature. No set of patterns contain the definitive list in which all women in the United States use contraception. However, the findings described here have important implications for the ways in which contraception fits into the lives of many women and how that behavior interacts with relationships, sexual activity, and life stage trajectories. Measuring contraceptive behavior, sexual activity, and life stage transition over time is necessary in examining reproductive well-being. This dissertation research is the first of its kind to attempt to keep pace with the complexities and changes within women's lives at the same time creating a practical statistical model of health behavior. The results from this study also provide evidence of the heterogeneity of lived experiences that complements the value of women's access to contraceptive care focused on quality of care, rights, health, and autonomy.

APPENDIX 1. MULTINOMIAL LOGISTIC REGRESSION FOR PREDICTORS OF LATENT CLASS MEMBERSHIP, RELATIVE RISK RATIOS

*Multinomial Logistic Regression for Predictors of Latent Class Membership, Relative Risk Ratios (Standard Error), NSFG 2015-2017 (n=5539)^*

	Classes					
	Single Abstinent Women	**High Risk of Pregnancy**	**Intermittent Users**	**Single Mothers**	**Method Switchers**	**Condom Users**
Predictors						
Age						
43-47	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
38-42	0.328 (0.272)	0.012 (0.208)	-0.228 (0.460)	-0.402 (0.185)*	1.802 (1.025)	0.403 (0.253)
33-37	0.181 (0.276)	0.386 (0.200)	0.466 (0.399)	-0.934 (0.209)**	1.980 (1.020)	0.799 (0.244)*
28-32	0.304 (0.269)	0.636 (0.192)*	1.010 (0.376)*	-1.230 (0.215)**	2.883 (1.004)*	1.082 (0.236)**
23-27	0.927 (0.257)**	0.753 (0.194)**	1.323 (0.373)**	-1.582 (0.247)**	3.269 (1.001)*	1.492 (0.234)**
18-22	1.959 (0.255)**	0.887 (0.204)**	2.514 (0.366)**	-2.841(0.514)**	3.524 (1.003)**	1.716 (0.240)**
13-17	5.33 (0.289)**	0.107 (0.379)	4.252 (0.411)**	-18.479(1832.0)	3.643 (1.040)**	2.607 (0.300)**
Education						
Less than High School	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
High School Graduate	-0.611 (0.158)**	-0.095 (0.147)	0.654 (0.224)*	-0.049 (0.198)	-0.403 (0.225)	0.029 (0.162)
Some College	-0.362 (0.158)*	-0.171 (0.150)	0.966 (0.225)**	0.105 (0.198)	-0.091 (0.215)	0.432 (0.156)*
College Degree+	0.700 (0.167)**	-0.113 (0.163)	1.714 (0.246)**	-0.029 (0.224)	-0.109 (0.237)	0.588 (0.170)*

Race and Ethnicity						
White Non-Hispanic	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Black Non-Hispanic	0.322 (0.131)*	0.228 (0.123)	0.741 (0.158)**	0.329 (0.165)*	0.088 (0.189)	0.387 (0.124)*
Hispanic	-0.196 (0.145)	-0.037 (0.139)	0.328 (0.174)	0.069 (0.196)	-0.004 (0.204)	0.100 (0.136)
Other	0.399 (0.177)	0.396 (0.181)*	0.189 (0.248)	0.353 (0.262)	0.463 (0.248)	0.194 (0.184)
Federal Poverty Level						
≤138% of FPL	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
139% to 199% of FPL	0.112 (0.153)	-0.073 (0.145)	-0.090 (0.191)	-0.502 (0.204)*	-0.290 (0.223)	-0.131 (0.149)
200% to 299% of FPL	-0.078 (0.155)	-0.197 (0.150)	-0.086 (0.188)	-0.278 (0.190)	-0.114 (0.207)	-0.190 (0.150)
300% to 399% of FPL	-0.155 (0.180)	-0.420 (0.184)*	-0.501 (0.244)*	-0.843 (0.251)*	-0.424 (0.265)	-0.145 (0.170)
≥400% of FPL	-0.311 (0.151)*	-0.319 (0.147)*	-0.130 (0.182)	-1.415 (0.228)**	-0.742(0.235)*	-0.253 (0.144)
Religion						
No Religion	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Catholic	-0.072 (0.154)	0.134 (0.154)	-0.287 (0.191)	-0.346 (0.239)	0.075 (0.229)	-0.176 (0.147)
Protestant	-0.087 (0.125)	0.198 (0.125)	-0.254 (0.151)	0.136 (0.182)	0.103 (0.186)	-0.214 (0.119)
Other Religions	0.358 (0.189)	-0.130 (0.221)	-0.263 (0.260)	0.186 (0.277)	0.524 (0.269)	0.090 (0.188)

^Stable Users (Class 7) is Reference Class
*indicates $p<0.05$
** indicates $p<0.001$

APPENDIX 2. MULTINOMIAL LOGISTIC REGRESSION RESULTS FOR PREDICTORS OF LATENT STATUS OF COVARIATES AT STUDY YEAR 1, RELATIVE RISK RATIOS

*Multinomial Logistic Regression for Predictors of Latent Status at Study Year 1, Relative Risk Ratios, NSFG 2015-2017 (n=5539)^*

	Time 1 Latent Status (β Parameters)					
	LS2	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
Age at Mean Age in Study Year 1 (29.03)	1.05**	1.19**	1.09**	1.06**	1.03**	1.05**
Federal Poverty Level at Mean (230%)	1.01**	1.00	0.99*	0.99	0.99	0.99
Race						
White	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Black	1.03	0.64**	0.99	1.28*	1.79**	1.21
Hispanic	0.94	1.40*	1.21	1.32*	1.72*	1.22
Other	0.69*	0.69*	0.98	0.89	0.96	0.88
Education						
<High School	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
High School Grad	3.15**	1.52*	1.96**	2.35**	3.02**	1.60
Some College	4.05**	1.55*	2.17**	3.84**	4.08**	2.02*
College or Greater	4.11**	1.03	1.88**	3.54**	4.68**	2.43*
Religion						
No Religion	*ref*	*ref*	*ref*	*ref*	*ref*	*ref*
Catholic	0.84	1.34	1.16	0.86	0.79	0.90
Protestant	0.69**	1.35*	1.15	0.77*	0.87	0.93
Other	0.43**	1.10	0.64*	0.70*	0.47*	1.40

Single Abstinent Users, (LS1); *Stable Users* (LS2); *Consistently Covered Mothers* (LS3); *High Chance of Pregnancy Women* (LS4); *Condom Users* (LS5); *Intermittent Users* (LS6); and *Unstable Users* (LS7).

^LS1 is reference class

*indicates $p<0.05$, ** indicates $p<0.001$

APPENDIX 3. FREQUENCY OF TRANSITION PATTERNS FOR WOMEN WHO REPORTED UNINTENDED PREGNANCIES IN STUDY YEAR 1 AND STUDY YEAR 2

Frequency of Transition Patterns for Women Who Reported Unintended Pregnancies; NSFG 2015-2017

Women who had an *Unintended* Pregnancy in Study Year 1 (n=202)

		Study Year 2					
Study Year 1	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	8	1	0	0	2	3	0
LS2	1	23	0	3	2	1	0
LS3	0	0	8	0	0	0	0
LS4	3	15	19	30	4	1	3
LS5	0	2	1	1	15	4	0
LS6	3	2	3	2	3	15	0
LS7	0	3	5	4	8	1	3

Women who had an *Unintended* Pregnancy in Study Year 2 (n=192)

		Study Year 3					
Study Year 2	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	4	0	0	0	0	0	1
LS2	0	17	0	9	2	0	4
LS3	0	0	8	3	0	0	1
LS4	3	10	7	53	2	3	5
LS5	0	2	0	1	11	2	5
LS6	3	1	0	6	3	5	0
LS7	0	1	0	6	2	1	11

APPENDIX 4. FREQUENCY OF TRANSITION PATTERNS FOR WOMEN WHO REPORTED INTENDED PREGNANCIES IN STUDY YEAR 1 AND STUDY YEAR 2

Frequency of Transition Patterns for Women Who Reported Intended Pregnancies; NSFG 2015-2017

Women who had an *Intended* Pregnancy in Study Year 1 (n=277)

	Study Year 2						
Study Year 1	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	3	0	0	2	2	0	0
LS2	0	12	0	6	1	0	0
LS3	0	0	12	0	0	0	0
LS4	4	21	48	82	7	5	1
LS5	0	0	0	3	11	1	0
LS6	1	4	1	4	3	10	0
LS7	0	2	5	2	17	1	6

Women who had an *Intended* Pregnancy in Study Year 2 (n=300)

	Study Year 3						
Study Year 2	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***	***LS7***
LS1	8	0	0	1	0	3	0
LS2	1	18	0	4	4	0	0
LS3	0	0	5	5	0	0	1
LS4	1	21	5	128	2	5	15
LS5	0	3	0	2	12	1	5
LS6	1	3	0	6	2	10	2
LS7	0	2	0	3	5	2	14

APPENDIX 5. RESULTS OF LONGITUDINAL MEASUREMENT INVARIANCE

Results of Longitudinal Measurement Invariance - Fit Statistics for Test of Full Measurement Invariance Model vs. Free Parameter Models (NSFG 2015-2017; n=5539)

	MI	G^2	AIC	BIC	DF	Diff.G	Diff.DF	*P*-value
6-solution model	Yes	21145.850	255104.300	256170.050	13633	-	-	
6-solution model	No	21036.057	253086.371	255423.079	13465	109.793	168	0.12
7-solution model	Yes	17771.251	248965.237	250302.390	13590	-	-	-
7-solution model	No	18512.332	247428.622	250248.559	13367	740.981	223	<0.01
Separate Parameters (7 Solution Model)								
7-solution most freq free			Best log-likelihood not replicated					
7-solution switching free		17728.318	248800.564	250323.065	13561	42.93	29	0.10
7-solution condoms free		17771.222	248764.784	250194.611	13576	0.029	14	0.99
7-solution sex free		17771.163	248969.306	250399.133	13576	.088	14	0.99
7-solution inconsistent sex free			Best log-likelihood not replicated					
7-solution marital status free		17777.268	248998.473	250706.322	13534	6.017	56	0.99
7-solution parity free			Best log-likelihood not replicated					
7-solution EC use free			Best log-likelihood not replicated					
7-solution, most freq, inconsistent sex, parity and EC, free			Best log-likelihood not replicated					

$G^2$is the likelihood ratio statistics.
Diff.G is the difference of likelihood ratio statistics
Diff.DF is the difference of degrees of freedom

APPENDIX 6. RESULTS OF TRANSITION PROBABILITY INVARIANCE

Results of Transition Probability Invariance; NSFG 2015-2017; n=5539

7-solution	G^2	AIC	BIC	DF	Diff.G	Diff.DF	*P*-value
Model 2 (transition invariance)	17816.916	249155.724	**250214.855**	13633	-	-	-
Model 1	17771.251	**248965.237**	250302.390	13590	45.665	43	0.25

$G^2$is the likelihood ratio statistics
Diff.G is the difference of likelihood ratio statistics
Diff.DF is the difference of degrees of freedom

APPENDIX 7. RESULTS OF 6-SOLUTION LATENT TRANSITION ANALYSIS MODEL, ITEM RESPONSE PROBABILITIES

6 Status Solution Model: Probabilities of Item Parameters on Contraceptive Behavior Dynamics and Exposure Variables; NSFG 2015-2017; n=5539

Latent Status	*LS1*	*LS2*	*LS3*	*LS4*	*LS5*	*LS6*
Probability						
Most Frequent Method						
Most Effective Method	0.10	0.10	0.56	0.05	0.04	0.11
Moderately Effective Method	0.10	0.26	0.27	0.19	0.08	0.08
Least Effective Method	0.0	0.02	0.11	0.76	0.48	0.05
No Method	0.80	0.62	0.06	0.0	0.40	0.75
Emergency Contraception Use						
No	1.00	0.95	0.99	0.96	0.93	0.99
Yes	0.00	0.05	0.01	0.04	0.07	0.01
Switching						
0	0.95	0.31	0.90	0.65	0.15	0.71
1	0.04	0.26	0.07	0.18	0.42	0.22
2+	0.01	0.43	0.03	0.17	0.43	0.07
Parity						
0	0.80	0.64	0.24	0.50	0.39	0.29
1	0.08	0.19	0.21	0.19	0.28	0.32
2	0.06	0.11	0.29	0.19	0.22	0.23
3+	0.06	0.06	0.26	0.12	0.11	0.16
Marital Status						
Single, Never Married	0.85	0.76	0.35	0.62	0.58	0.36
Married	0.03	0.08	0.49	0.27	0.30	0.27
Single, Previously Married	0.11	0.11	0.12	0.08	0.08	0.07
Married within Study Period	0.00	0.03	0.03	0.02	0.03	0.04
Dissolution within Study Period	0.01	0.02	0.02	0.01	0.02	0.01

Mean (in months per year)						
Condom Use	0.0	1.5	0.02	10.0	5.4	0.0
Inconsistent use	0.0	0.4	0.01	0.04	5.7	9.2
Sexual Activity	0.0	3.5	11.1	10.8	10.2	11.0

APPENDIX 8. RESULTS OF 6-SOLUTION LATENT TRANSITION ANALYSIS MODEL; PREVALENCES AND TRANSITION MATRIX

6 Status Solution Model - Latent Status Prevalence (δ Estimate) and Transition Matrix (τ Estimates) Over Three Time Points on Women's Contraceptive and Exposure Variables; NSFG 2015-2017; n=5539

				δ Estimate		
Time	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***
Year 1	0.30	0.09	0.32	0.14	0.13	0.02
Year 2	0.26	0.11	0.32	0.15	0.11	0.05
Year 3	0.23	0.11	0.33	0.17	0.11	0.05
				τ Estimate		
LS1	0.789	**0.137**	0.025	0.008	0.025	0.016
LS2	**0.150**	0.471	0.091	0.088	**0.115**	0.085
LS3	0.018	0.022	0.842	0.087	0.022	0.008
LS4	0.020	0.022	**0.164**	0.733	0.019	0.042
LS5	0.023	0.083	0.092	0.036	0.645	**0.122**
LS6	0.000	0.087	**0.157**	**0.279**	0.154	0.323

APPENDIX 9. RESULTS OF 6-SOLUTION LATENT TRANSITION ANALYSIS MODEL; TRANSITION PROBABILITY INVARIANCE

6 Status Solution Model - Results of Transition Probability Invariance for 6 Solution Model; NSFG 2015-2017; n=5539

6-solution	G^2	AIC	BIC	DF	Diff.G	Diff.DF	*P*-value
Model 2 (transition invariance)	21124.121	255254.033	256121.197	13662	-	-	-
Model 1	21145.850	255104.300	256170.050	13633	21.729	29	0.75

APPENDIX 10. SENSITIVITY ANALYSIS; FIT STATISTICS OF LCA AT EACH TIME PERIOD WITHOUT PARITY OR MARITAL STATUS VARIABLES

Sensitivity Analysis: Results of LCAaAt Each Time Point, ***without Parity or Marital Status****, NSFG 2015-2017; n=5539*

	Number of Parameters Estimated	Log-likelihood	AIC	BIC	ABIC	Entropy	LMR-LTR (*p*)	% in Smallest Class
Time 1								
2-solution	19	-51739.124	103516.248	103642.020	103581.644	0.985	-	33.4%
3-solution	29	-40817.950	81693.899	81885.867	81793.714	0.985	20219.101(<0.001)	16.6%
4-solution	39	-33367.155	66812.309	67070.472	66946.542	0.984	14730.692(<0.001)	16.1%
5-solution	49	-31775.453	63648.906	63973.265	63817.558	0.979	3055.099(<0.001)	9.2%
6-solution	59	-30989.371	62096.743	62487.297	62299.814	0.974	1166.924(<0.001)	5.1%
7-solution	69	**-30756.952**	**61651.903**	**62108.654**	**61889.393**	0.974	459.509 (0.0008)	2.2%
8-solution	Best log-likelihood not replicated							
Time 2								
2-solution	19	-53248.452	106534.904	106660.676	106600.300	0.981	-	30.6%
3-solution	29	-42173.517	84405.034	84597.002	84504.849	0.981	20397.589 (<0.001)	16.2%
4-solution	39	-34388.320	68854.640	69112.803	68988.873	0.984	13781.708 (<0.001)	16.1%
5-solution	49	-32838.854	65775.709	66100.067	65944.361	0.978	3063.391 (<0.001)	10.0%
6-solution	59	-32091.709	64301.417	64691.972	64504.488	0.972	1477.154 (<0.001)	5.7%
7-solution	69	-31806.762	63751.523	64208.274	63989.013	0.971	**322.649 (<0.001)**	2.2%
8-solution	79	**-31659.769**	**63477.538**	**64000.484**	**63749.447**	0.968	290.613 (0.1596)	3.0%
Time 3								
2-solution	19	-55066.099	110170.199	110295.971	110235.594	0.968	-	36.1%
3-solution	29	-46041.568	92141.136	92333.103	92240.950	0.976	16605.730 (<0.001)	28.0%
4-solution	39	-39271.819	78621.638	78879.801	78755.871	0.979	13384.220 (<0.001)	18.7%
5-solution	49	-37637.707	75373.414	75697.773	75542.066	0.977	1204.205 (<0.001)	7.2%
6-solution	59	-36174.651	72467.302	72857.857	72670.373	0.972	2892.554 (<0.001)	5.3%
7-solution	69	-35867.173	71872.346	72329.096	72109.835	0.961	607.904 (<0.001)	5.0%
8-solution	79	-35556.997	71271.993	71794.939	71543.902	0.955	613.238 (<0.001)	3.3%
9-solution	89	**-35367.383**	**70912.766**	**71501.907**	**71219.093**	0.943	374.879 (<0.001)	3.2%
10-solution	Model did not converge							

APPENDIX 11. SENSITIVITY ANALYSIS; RESULTS OF LCA AT STUDY YEAR 1 WITHOUT PARITY OR MARITAL STATUS VARIABLES

Sensitivity Analysis: Latent Class Membership at Study Year 1 without Marital Status and Parity: Probabilities and Means of Class Indicators; NSFG, 2015-2017; n=5539; 6-Solution Model

	7 Class Model					
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6**
Latent Class Prevalence	*0.30*	*0.12*	*0.09*	*0.06*	*0.12*	*0.31*
Probability						
Most Frequent Method						
Most Effective Method	0.10	0.04	0.11	0.17	0.00	0.48
Moderately Effective Method	0.09	0.20	0.24	0.23	0.00	0.27
Least Effective Method	0.00	0.76	0.01	0.31	0.00	0.10
No Method	0.81	0.00	0.64	0.29	1.00	0.04
Emergency Contraception Use						
No	1.00	0.97	0.96	0.97	0.99	1.00
Yes	0.00	0.03	0.04	0.03	0.01	0.00
Switching						
0	0.95	0.70	0.30	0.01	0.79	0.94
1	0.05	0.16	0.28	0.62	0.17	0.04
2+	0.00	0.14	0.42	0.37	0.05	0.01
Mean (in months)						
Condom Use	0.00	10.16	1.56	2.53	0.00	0.00
Inconsistent Use	0.00	0.00	0.27	3.85	10.32	0.00
Sex	0.02	10.84	3.11	10.57	10.90	11.26

APPENDIX 12. SENSITIVITY ANALYSIS; RESULTS OF LTA WITHOUT PARITY OR MARITAL STATUS VARIABLES

Sensitivity Analysis: Probabilities of Item Parameters on Contraceptive Behavior Dynamics Variables; NSFG 2015-2017; N=5539; 6 Status Model – Without Parity or Marital Status

Latent Status	*LS1*	*LS2*	*LS3*	*LS4*	*LS5*	*LS6*
Probability						
Most Frequent Method						
Most Effective Method	0.11	0.10	0.55	0.11	0.04	0.05
Moderately Effective Method	0.09	0.23	0.28	0.08	0.08	0.19
Least Effective Method	0.00	0.02	0.11	0.05	0.49	0.76
No Method	0.80	0.65	0.06	0.76	0.39	0.00
Emergency Contraception Use						
No	1.00	0.95	0.99	0.99	0.93	0.96
Yes	0.00	0.05	0.01	0.01	0.07	0.04
Switching						
0	0.95	0.31	0.89	0.71	0.14	0.95
1	0.04	0.26	0.08	0.22	0.42	0.04
2+	0.01	0.43	0.03	0.07	0.44	0.01
Mean (in Months Per Year)						
Condom Use	0.0	1.52	0.03	0.01	5.43	9.96
Inconsistent Use	0.0	0.44	0.01	9.18	5.69	0.03
Sexual Activity	0.02	3.32	11.11	10.98	10.18	10.82

APPENDIX 13. SENSITIVITY ANALYSIS; RESULTS OF LTA WITHOUT PARITY OR MARITAL STATUS VARIABLES; LATENT STATUS PREVALENCE AND TRANSITION MATRIX

Sensitivity Analysis: Latent Status Prevalence (δ Estimate) and Transition Matrix (τ Estimates) Over Three Time Points on Women's Contraceptive Behavior Variables; NSFG 2015-2017; N=5539; 6 Status Model without Parity or Marital Status

				δ Estimate		
Time	***LS1***	***LS2***	***LS3***	***LS4***	***LS5***	***LS6***
Year 1	0.30	0.09	0.32	0.14	0.02	0.13
Year 2	0.26	0.10	0.32	0.15	0.04	0.11
Year 3	0.23	0.11	0.33	0.17	0.05	0.11
				τ Estimate		
LS1	0.788	**0.132**	0.030	0.009	0.016	0.026
LS2	**0.155**	0.463	0.088	0.091	0.083	**0.120**
LS3	0.019	0.020	0.840	0.088	0.009	0.023
LS4	0.021	0.026	**0.163**	0.729	0.041	0.020
LS5	0.000	0.082	**0.162**	**0.281**	0.318	**0.155**
LS6	0.023	0.079	0.098	0.038	**0.120**	0.642

APPENDIX 14. SENSITIVITY ANALYSIS; FIT STATISTICS OF LCAS AT ALL THREE STUDY PERIODS WITHOUT WOMEN WITH PREGNANCIES

Sensitivity Analysis: Results of LCA at Each Time Point, ***without Women with Pregnancies****, NSFG 2015-2017; N=4329*

	Number of Parameters Estimated	Log-likelihood	AIC	BIC	ABIC	Entropy	LMR-LTR (*p*)	% in Smallest Class
Time 1								
2-solution	33	-44242.55	88551.111	88761.423	88656.562	0.985	-	40.0%
3-solution	50	-36453.078	73006.157	73324.811	73165.932	0.983	14669.003(<0.001)	16.8%
4-solution	67	-30801.733	61737.466	62164.463	61951.564	0.988	11160.011(<0.001)	7.8%
5-solution	84	-29518.090	59204.180	59739.520	59472.602	0.981	2521.997(<0.001)	7.6%
6-solution	101	-28998.255	58198.510	58842.192	58521.255	0.970	1032.418 (<0.001)	7.0%
7-solution	118	**-28652.423**	**57540.846**	**58292.871**	**57917.915**	0.942	1013.282 (<0.001)	6.8%
8-solution	Best log-likelihood not replicated with maximum starts							
Time 2								
2-solution	33	-46151.476	92368.951	92579.263	92474.403	0.981	-	36.5%
3-solution	50	-38143.948	76387.551	76706.551	76547.671	0.984	14411.607 (<0.001)	25.2%
4-solution	67	-32228.662	64591.324	65018.321	64805.422	0.986	9463.562 (<0.001)	8.3%
5-solution	84	-30770.645	61709.291	62244.631	61977.713	0.980	632.890 (<0.001)	7.9%
6-solution	101	-30304.780	60811.560	61455.242	61134.305	0.972	925.231 (<0.001)	5.9%
7-solution	118	**-29903.139**	**60042.279**	**60794.304**	**60419.348**	0.943	840.383 (<0.001)	5.9%
8-solution	Best log-likelihood not replicated with maximum starts							
Time 3								
2-solution	33	-48969.723	98005.447	98215.759	98110.898	0.979	-	32.8%
3-solution	50	-40832.498	81764.995	82083.650	81924.770	0.979	16160.916 (<0.001)	29.6%
4-solution	67	-36499.090	73132.179	73559.176	73346.278	0.980	8606.354 (<0.001)	18.4%
5-solution	84	-35037.116	70242.232	70777.572	70510.654	0.975	2903.549 (<0.001)	10.2%
6-solution	101	-34038.811	68279.622	68923.304	68602.367	0.975	2155.674 (<0.001)	3.4%
7-solution	118	-33580.982	67397.963	68149.988	67775.032	0.968	909.271 (<0.001)	3.4%
8-solution	135	**-33176.951**	**66623.902**	**67484.269**	**67055.294**	0.939	827.889 (<0.001)	3.4%
9-solution	Best log-likelihood not replicated with maximum starts							

APPENDIX 15. SENSITIVITY ANALYSIS; RESULT OF LCA AT STUDY YEAR ONE WITHOUT WOMEN WITH PREGNANCIES

Sensitivity Analysis: Latent Class Membership at Study Year 1 without Women with Pregnancies: Probabilities and Means of Class Indicators (NSFG, 2015-2017; N=4329) 6-Solution Model

	7 Class Model						
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**	**Class 6**	**Class 7**
Latent Class Prevalence	*0.07*	*0.31*	*0.08*	*0.07*	*0.11*	*0.12*	*0.24*
Probability							
Most Frequent Method							
Most Effective Method	0.53	0.01	0.02	0.10	0.15	0.05	0.80
Moderately Effective Method	0.05	0.09	0.01	0.25	0.65	0.21	0.12
Least Effective Method	0.00	0.00	0.00	0.02	0.15	0.74	0.07
No Method	0.42	0.90	0.97	0.63	0.05	0.00	0.01
Emergency Contraception Use							
No	1.00	1.00	1.00	0.95	0.99	0.97	1.00
Yes	0.00	0.00	0.00	0.05	0.01	0.03	0.00
Switching							
0	0.96	0.95	0.85	0.26	0.87	0.66	0.97
1	0.04	0.05	0.11	0.26	0.10	0.18	0.02
2+	0.00	0.00	0.04	0.48	0.03	0.16	0.01
Parity							
0	0.09	0.96	0.37	0.70	0.64	0.50	0.05
1	0.31	0.03	0.24	0.14	0.26	0.18	0.16
2	0.28	0.01	0.23	0.11	0.08	0.20	0.39
3+	0.32	0.00	0.16	0.05	0.02	0.12	0.40
Marital Status							
Single, Never Married	0.30	0.98	0.32	0.79	0.73	0.63	0.17
Married	0.15	0.00	0.50	0.04	0.17	0.25	0.66
Single, Previously Married	0.49	0.02	0.12	0.11	0.06	0.09	0.14
Married within Year	0.01	0.00	0.04	0.02	0.03	0.02	0.02
Dissolution within Year	0.05	0.00	0.02	0.04	0.01	0.01	0.01

Mean (in Months)							
Condom Use	0.01	0.00	0.09	2.03	0.08	10.12	0.00
Inconsistent Use	0.06	0.00	10.50	0.19	0.02	0.08	0.00
Sex	0.23	0.01	11.01	3.25	10.88	10.76	11.4

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